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INFORMATION REPORT INFORMATION REPORT

# CENTRAL INTELLIGENCE AGENCY



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|---|---|---|---|
| COUNTRY | USSR | REPORT | [redacted] |
| SUBJECT | Operation Manual for the Soviet Type 25-I Synchroscope | DATE DISTR. | 28 February 1958 |
| | | NO. PAGES | 1 |
| | | REFERENCES | RD |
| DATE OF INFO. | [redacted] | | |
| PLACE & DATE ACQ. | [redacted] | | |

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SOURCE EVALUATIONS ARE DEFINITIVE. APPRAISAL OF CONTENT IS TENTATIVE.

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[redacted] English-language operation manual for the Soviet Type 25-I synchroscope [redacted] 25X1 In addition to operating and repair procedures for use with the synchroscope, the manual contains photographs, sketches, and wiring diagrams of the equipment.

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(Note: Washington distribution indicated by "X"; Field distribution by "#".)

INFORMATION REPORT INFORMATION REPORT

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# SYNCHROSCOPE TYPE 25M

## DESCRIPTION

Sanitized Copy Approved for Release 2010/04/29 : CIA-RDP80T00246A040400550001-2

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Part 1

General Description

# Part 1

## GENERAL DESCRIPTION

### 1. Application

The type 25И Synchroscope is a laboratory instrument designed for developing, aligning, and checking radar equipment in scientific research institutes and at factories.

The Synchroscope is a sufficiently universal instrument as it provides for the investigation of both periodic processes at various frequencies and pulse processes of short pulse duration.

The Synchroscope provides for:

1. The amplification of small-amplitude and short-duration pulses without noticeable distortion.

2. The measurement of the duration of the pulse under test.

3. The measurement of the amplitude of the pulse under test.

4. The time delay of the triggered sweep from 10 to 100 microseconds.

### 2. Specifications

The Synchroscope 25И complies with the following specifications:

1. The Synchroscope provides for:

   a) the observation of pulses of any shape and polarity;

   b) the observation of voltage curves of undamped oscillations;

   c) the measurements of pulse durations and amplitudes;

2. The Synchroscope provides for the observation of:

   a) pulses with durations from 0.? to 3000 microseconds;

   b) undamped oscillations with frequencies from 50 c.p.s. to 1 mc.

3. The Synchroscope incorporates a vertical-deflection amplifier with a frequency response from 30 c.p.s. to 5 mc.

4. The frequency distortion of the vertical-deflection amplifier does not exceed:

a) ±1 db for frequencies from 100 c.p.s. to 2 mc;

b) -2 db for frequencies from 2 c.p.s. to 5 mc.

5. The vertical-deflection amplifier incorporates a delay circuit for delaying the front edge of the pulse under test by 0.3-0.1 microseconds with respect to the start of the sweep.

6. Input impedance:

a) without the external divider:

1) low - 75 ohms ±10%;

2) high - 0.51 megohms ±10% with a parallel capacitance not exceeding 35 mmf;

b) with the external divider - not less than 5 megohms with a parallel capacitance not exceeding 15 mmf.

7. The input of the Synchroscope is designed for the following voltages:

a) without the external divider:

1) for low-impedance from 0.1 to 1 volt;

2) for high impedance not in excess of 100 volts;

b) with the external divider - 500 volts.

Note. At an input voltage of 0.1 volts, the effective image on the screen of the cathode-ray tube measures not less than 25 mm from peak to peak.

1st 8. The input of the vertical-deflection amplifier is provided with an attenuator, having attenuation factors, for the high-ohm input, of 10 and 100 with an accuracy of ±5%.

2nd 9. The vertical-deflection amplifier channel is provided with a second attenuator, having attenuation factors of 2, 5, and 10.

3rd In addition, the vertical-deflection amplifier channel is provided with smooth gain regulation.

bears all the inscriptions relating to the controls.

The horizontal panels are rigidly attached to the vertical panel and to each other. Thus the chassis represents a constructional whole. As has already been mentioned, the chassis slides into an aluminium case, in which it is secured by means of two screws, located at the back of the Synchroscope.

The metal case is louvered at the sides, behind, and at the top, in order to ensure ventilation and an even temperaturre inside the Synchroscope.

In addition, a handle is attached to the top of the case for carrying the Synchroscope.

The back of the case is provided with a door for giving access to the jacks which serve for applying voltage directly to the deflection plates of the cathode ray tube, the switches ПК-3 and ПК-4, and the supply-voltage switch.

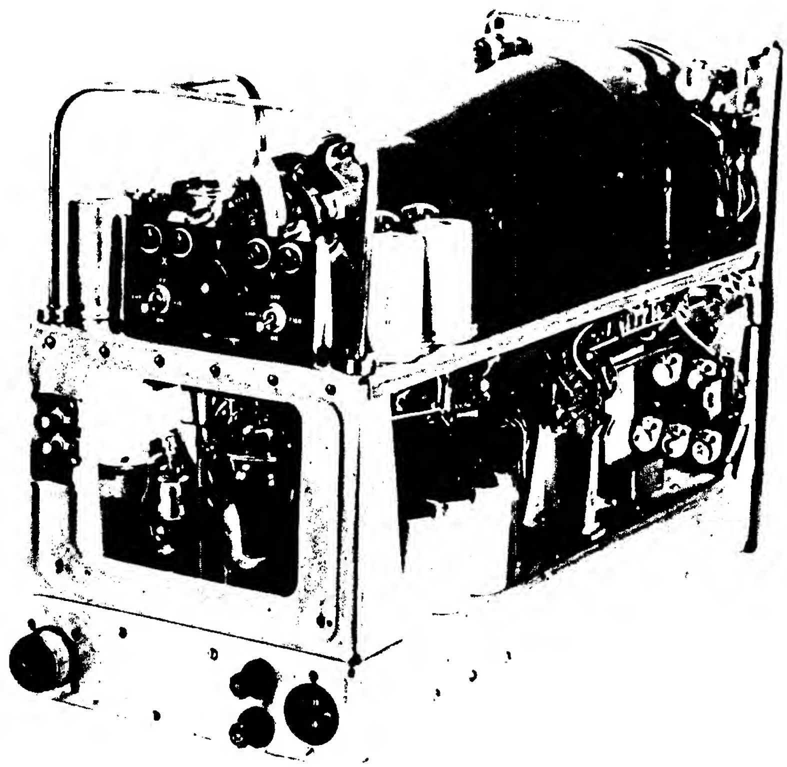
The back of the case is also provided with openings for the receptacle of the four-pin connector for supplying the single-stage amplifier (cathode repeater), the fuse, and the detachable power cord.

The overall dimensions of the Synchroscope (including projecting parts) are: 257x546x425 mm.

The weight of the Synchroscope does not exceed 28 kg.

The general view of the Synchroscope, the arrangement of the controls, the arrangement of the other parts and the wiring are shown in Figs. 3, 4, 5, 6, 7 and 8.

25-1 SYNCHROSCOPE.



of Synchroscope with case removed.

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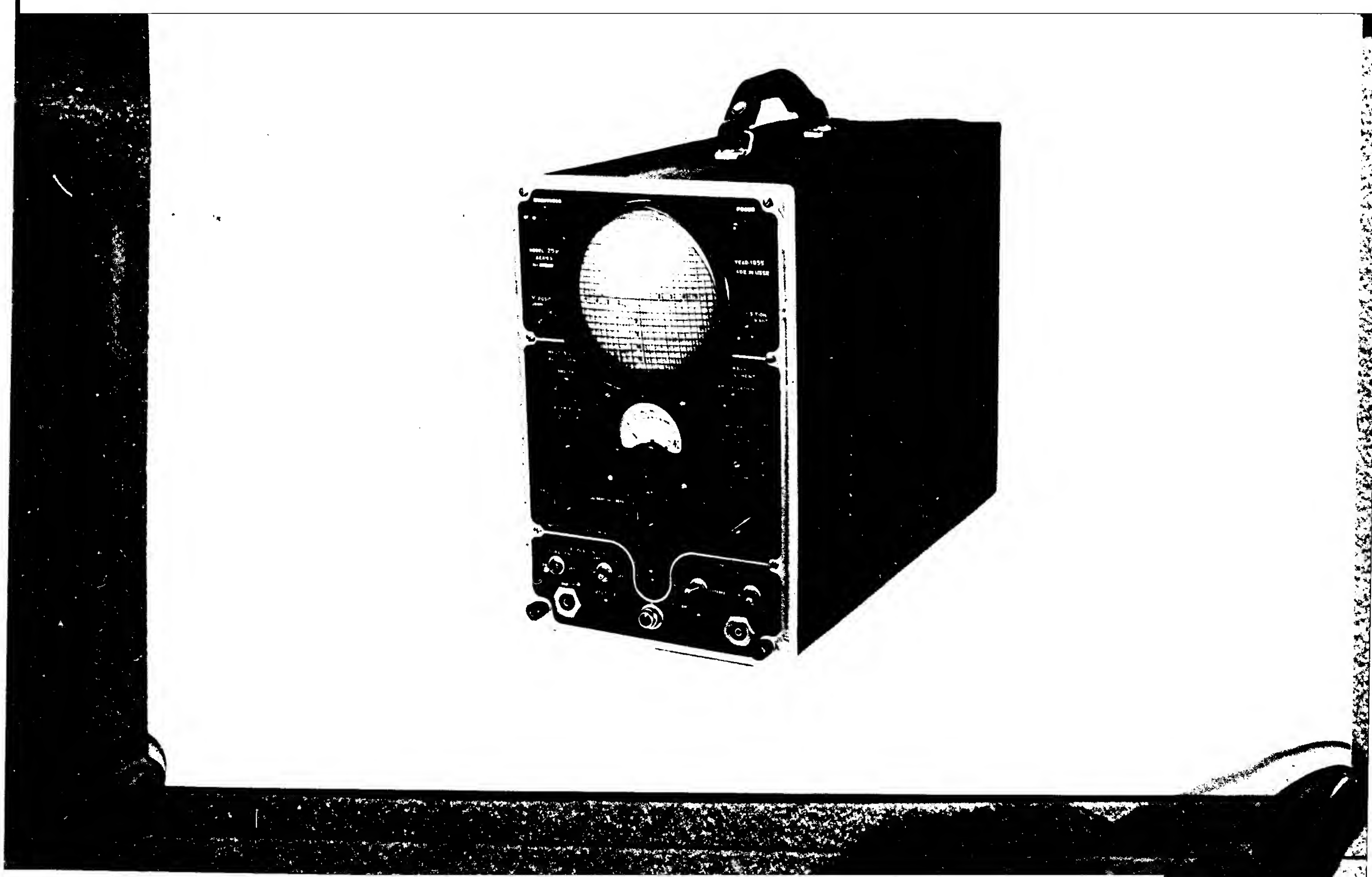
25-1 SYNCHROSCOPE.



10. The Synchroscope has three sweep systems:

a) a triggered sweep, synchronized with the pulse under test, having durations of 2, 10, 50, and 250 microseconds;

b) a repetitive sweep (saw-tooth), having the following frequency ranges: from 10 to 100 c.p.s., from 100 to 1000 c.p.s., from 1000 to 10,000 c.p.s., and from 10,000 to 100,000 c.p.s.

c) an one-pulse sweep.

Note. Pulses with durations from 250 to 3000 microseconds are observed with the aid of the repetitive (saw-tooth) sweep.

11. The repetitive and the one-pulse sweep can be regulated in amplitude from zero to the maximum value.

12. The Synchroscope is provided with two synchronization means:

a) internal synchronization by the signal under test;

b) external synchronization by means of an external signal.

13. The synchronization amplifier assures stable operation with:

a) internal synchronization with 0.1 volts applied to the input of the Synchroscope;

b) external synchronization with from 2 to 20 volts for the repetitive sweep and from 5 to 50 volts for the triggered sweep.

14. The Synchroscope provides for the smooth delay adjustment of the sweep from 10 to 100 microseconds.

15. The Synchroscope provides for the measurement of pulse duration with the aid of calibration markers, spaced at 0.1, 0.5, 2, and 10 microseconds depending on the duration of the triggered sweep. The measuring accuracy is within 15%.

16. The Synchroscope provides for the measurement of the

amplitude of the [illegible] volts with an accuracy within [illegible].

17. The Synchroscope has provision for applying external signals directly to the vertical and horizontal plates of the cathode ray tube.

18. The Synchroscope normally operates at [illegible] tures ranging from [illegible] to [illegible] and relative humidity from 60 to 70%.

19. The Synchroscope [illegible] at a relative humidi- ty of 95% and a temperature of [illegible].

20. Lengthy storage of the synchroscope in normal packing at temperatures ranging from -40°C to +40°C does not put it out of order nor decrease the accuracy of its operation in normal working conditions.

The Synchroscope can operate continuously during 8 hours.

21. Replacement of valves does not disturb normal operation of the Synchroscope.

22. The Synchroscope functions normally with changes of ±10% in the supply voltage.

23. The Synchroscope is fully powered from a-c mains of 115, 127, 220 volts, 400 and 50 cycles.

3. Complement

The type 25И Synchroscope is furnished with:

a) a working set of valves, containing the following types:

| | | | |
|---|---|---|---|
| 6Ж4 . . . . . . . . . . . . | five | 6H7C . . . . . . . . . . . | two |
| 6П9 . . . . . . . . . . . . | two | 5Ц3C . . . . . . . . . . . | one |
| 6П6C . . . . . . . . . . . . | four | 2Ц3C . . . . . . . . . . . | one |
| 6H8C . . . . . . . . . . . . | two | Pilot lamp . . . . . . . . | one |
| 6H9C . . . . . . . . . . . . | one | | |

b) four cables of two types for connecting the synchroscope to the objects to be tested;

c) a cable with an external head (separator);

d) a log booklet;

e) a packing box.

4. The Circuit and a Brief Description of It

The block diagram (Fig.1) and the circuit diagram (Fig.2) show that the Synchroscope consists of the following main elements:

a) input attenuator;

b) intermediate amplifier;

c) delay line for signal under test;

d) second attenuator;

e) three-stage vertical-deflection amplifier;

f) synchronization amplifier;

g) repetitive-sweep saw-tooth oscillator;

h) triggered-sweep oscillator;

i) horizontal-deflection amplifier;

j) triggered-sweep delay;

k) cathode ray tube;

l) power block;

m) duration and amplitude calibrator;

The signal to be investigated is fed from the coaxial input jack to the input attenuator. The attenuator makes it possible to match the input impedance of the synchroscope with the output impedance of the source of the signal to be investigated and to attenuate it by a factor of 10 or 100.

In addition the signal under test can be applied to the attenuator through the external divider supplied with the synchroscope, which also attenuates the signal by a factor of

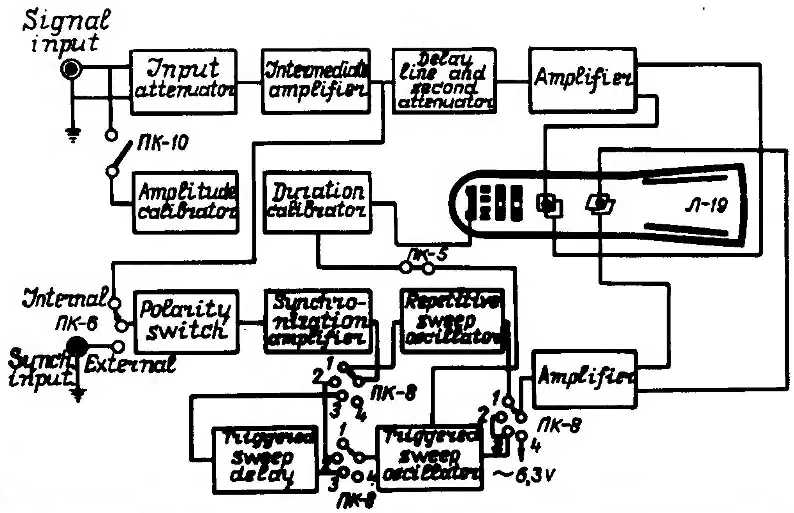

Signal input
Input attenuator
Intermediate amplifier
Delay line and second attenuator
Amplifier
ПК-10
Amplitude calibrator
Duration calibrator
Л-19
ПК-5
Internal
ПК-6
Polarity switch
Synchronization amplifier
Repetitive sweep oscillator
Synch. input
External
ПК-8
Amplifier
ПК-8
Triggered sweep delay
Triggered sweep oscillator
ПК-8
~6,3 V

Fig.1. Block diagram

From the attenuator, the signal under test is impressed on the grid of valve Л1, which operates as a cathode repeater with R13 as its load, then the signal passes through the delay line which is loaded by the second attenuator. From the plate of valve Л1, voltage is fed to the synchronization amplifier (internal synchronization).

The second attenuator consists of four sections and attenuates the incoming signal by a factor of 2, 5 or 10. The input signal, adjusted in voltages with the aid of the input and the second attenuators, is applied to the grid of the first valve of the three-stage vertical-deflection amplifier. After amplification, the signal is applied (balanced output) to the vertical-deflection plates of the cathode ray tube.

The synchronizing pulses taken inside the Synchroscope

from the plate of valve Л1 of the signal channel, or obtained from an external source, operating in synchronism with the signal, are fed to the sweep-synchronization channel through ПК-6 and the pulse synchronization amplifier (valves Л14, Л15).

The amplitude of the voltage fed to the sweep channel for both internal and external synchronization, is regulated by the potentiometer R100.

As the triggered sweep oscillator is triggered only by negative pulses, the synchronization pulses before being fed to the triggered sweep channel, first pass through the polarity-change switch, which ensures triggering of the pulse oscillator with negative starting pulses, regardless of the polarity of the synchronization pulses.

The triggered sweep oscillator (valves Л9 and Л10) operates only when it receives a starting pulse from the synchronization amplifier and generates a saw-tooth voltage which is amplified by the sweep amplifier (valves Л12 and Л13) and applied to the horizontal-deflection plates of the cathode ray tube, causing the beam to move from left to right across the screen. The sweep speed can be adjusted, providing the following times of travel of the beam across the screen: 2, 10, 50, and 250 microseconds. This makes it possible to observe pulses having durations from 0.2 to 250 microseconds.

The synchronizing signal can also be fed to the repetitive -sweep saw-tooth oscillator (valve Л8).

In this case, saw-tooth voltage is applied to the horizontal deflection plates of the cathode ray tube. The frequency of the saw-tooth voltage is adjustable to any value ranging from 10 to 100,000 cycles, making it possible to observe both slow and fast periodic processes.

As in the case of the triggered sweep, the saw-tooth voltage is fed to the ~~vertical deflection~~ horizontal deflection plates of the cathode ray tube through the sweep amplifier.

The block diagram and the circuit diagram show that in the third position of the switch ПК-8, triggered sweep delay, which is brought about with the aid of a multivibrator (valve Л16), can be introduced between the synchronization amplifier and the triggered sweep oscillator.

In this case, the synchronizing (starting) signal is fed to the input of the triggered sweep oscillator with a time delay of from 10 to 100 microseconds.

The various types of sweep are switched with the aid of the switch ПК-8, all the wafers of which are mounted on one shaft.

Position 1 of the switch ПК-8 gives a repetitive saw-tooth sweep. Position 2 of the switch ПК-8 gives a triggered sweep. Position 3 of the switch ПК-8 gives a triggered sweep delayed with respect to the starting pulse. Position 4 of the switch ПК-8 gives an a-c sweep. In addition to the above-mentioned main elements, the circuit of the Synchroscope includes the following additional elements: 1) amplitude calibrator, 2) duration calibrator.

The amplitude calibrator makes it possible to apply a voltage of a known value to the input of the Synchroscope, and by comparing it to the amplitude of the pulse under test to determine the amplitude of the latter.

The pulse duration calibrator (negative-resistance oscillator, valve Л7) makes it possible to superimpose calibration markers (by modulating the trace intensity) on the pulse under test, and in this way to determine the duration of the pulse.

The pulse duration calibrator is started by the triggered sweep oscillator, therefore the calibration markers are synchronized with the operation of the oscillator and appear on the screen (on the trace) as stable, stationary markers.

The power block is not included in the block diagram, as its inter-relation with all the elements of the circuit is obvious. The power block consists of one power transformer and two rectifiers. One rectifier (high-voltage) supplies the cathode ray tube, the other supplies all the other elements of the circuit.

## 5. Constructional Features

### A. The Design of the Synchroscope

The Synchroscope is assembled on a chassis which is slid into a metal case and secured by screws.

The chassis of the Synchroscope consists of a vertical panel on which are arranged all the controls, and two horizontal panels on which are mounted all the valves, the parts, and the parts-mounting boards. On the upper horizontal panel are arranged the valves of the vertical-deflection amplifier, the valves of the repetitive-sweep oscillator, the valves of the triggered-sweep oscil: e or, the valves of the horizontal-deflection oscillator, and the valve of the diode voltmeter.

In addition, the following elements are arranged on the upper panel: delay line, electrolytic condensers, paper-oil condensers, correction coils, internal adjusting potentiometers, parts-mounting boards, and other parts, pertaining to the signal channel and sweep channel.

On the same panel are arranged the cathode ray tube socke a board with the switches ПК-3 and ПК-4 and the input jacks Г3 and Г4, and the power transformer switch.

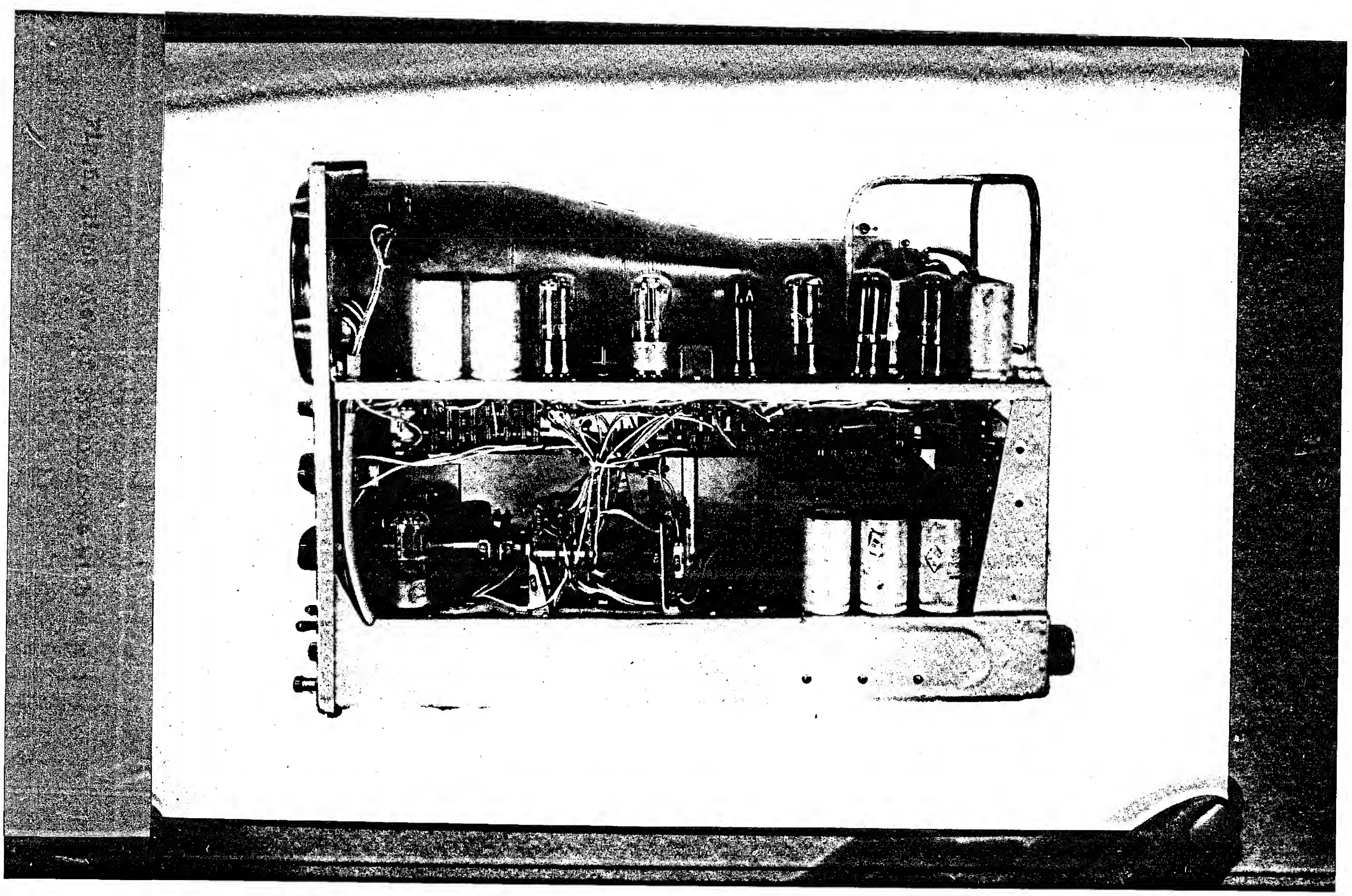
The cathode ray tube, having a diameter of 130 mm, is arranged above the panel and is protected from the action of electro-magnetic fields by means of a screen.

The following elements are arranged on the lower horizontal panel: the duration-calibrator valve; the synchronization-amplifier valve; the sweep-delay valve, the rectifier valves; the power transformer; the supply-filter condensers; the sweep switch (ПК-8); the sweep speed and frequency switch, and other parts.

The power transformer is housed in a magnetic shield. The coils of the negative-resistance oscillator are housed in a common aluminium shield and are located under the panel. On brackets at the rear of the chassis are arranged the receptacle of a four-pin connector (for supplying voltage to a one-stage amplifier), an interlocking button, fuses, and the sunk plug of the supply-cord connector.

The following parts are arranged on the vertical panel of the chassis: the brightness-control potentiometer; the focus-control potentiometer, the horizontal and vertical beam-positioning-control potentiometers, the horizontal amplification-control potentiometer, the synchronization amplification-control potentiometer, the sweep delay control potentiometer, the smooth sweep frequency control potentiometer, the calibration signal amplitude control potentiometer, the input attenuator switch, the synchronization polarity switch, the synchronization switch (internal-external), the calibration signal off-on switch, the coaxial test-signal input and synchronization jacks, the ground binding post, the pilot lamp, and the pulse amplitude calibration meter.

The vertical panel is covered with a facing panel which



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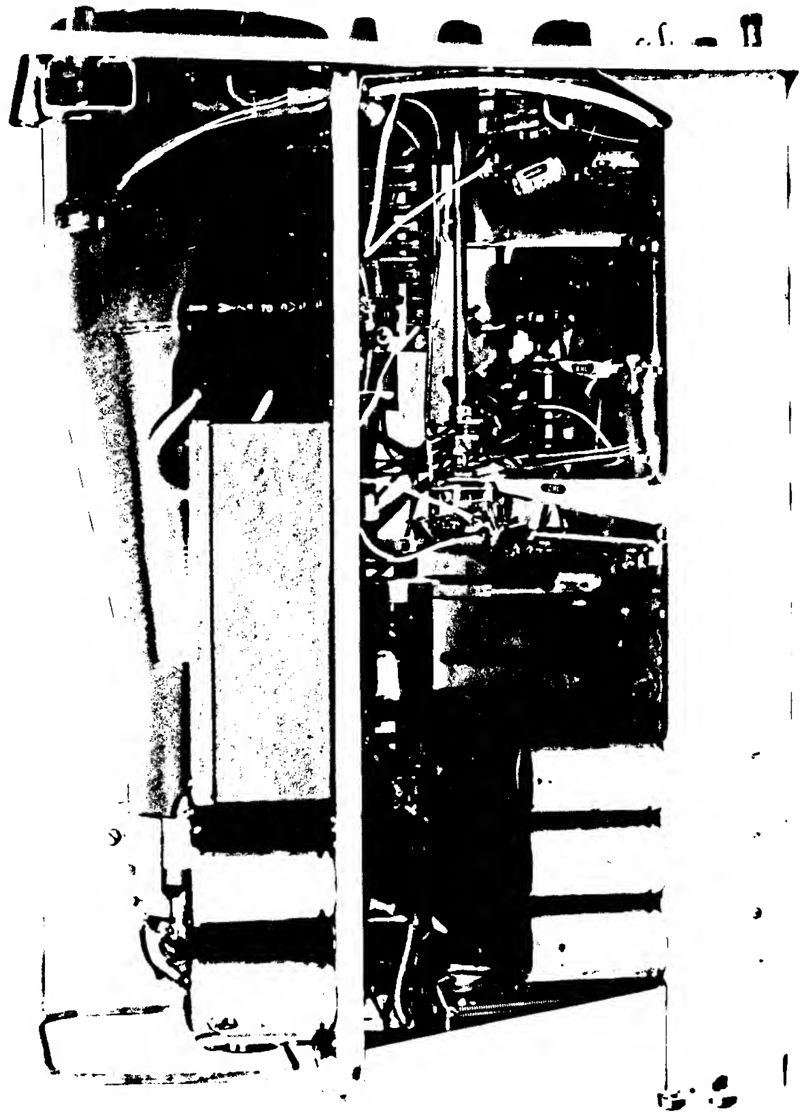


Fig.6. Left view of Synchroscope with case removed.

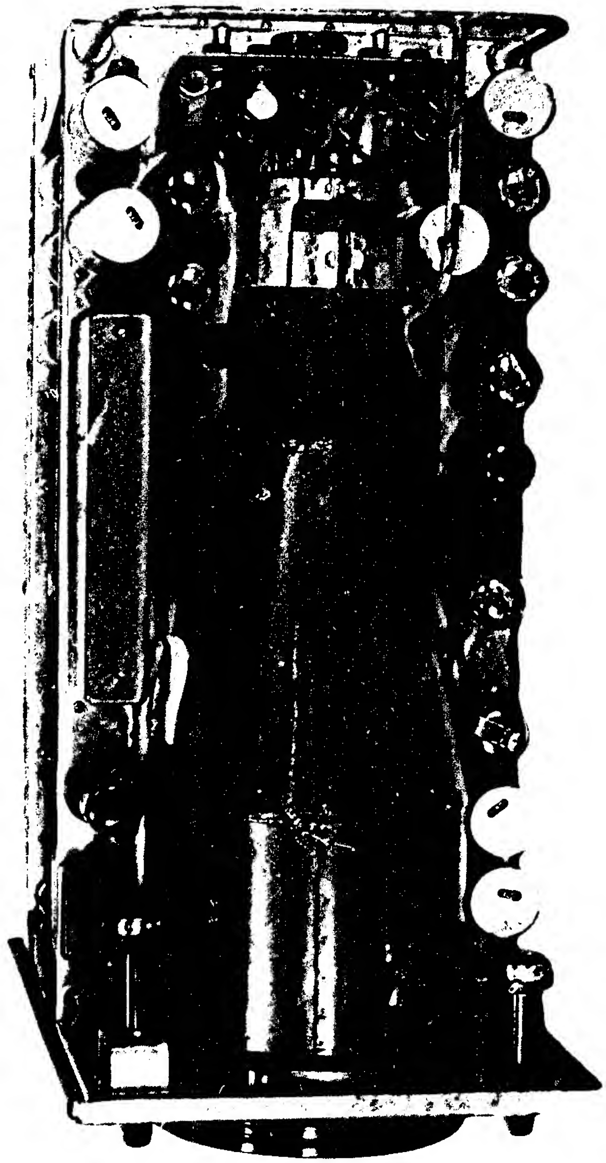


Fig.7. Top view of Synchroscope with case removed.

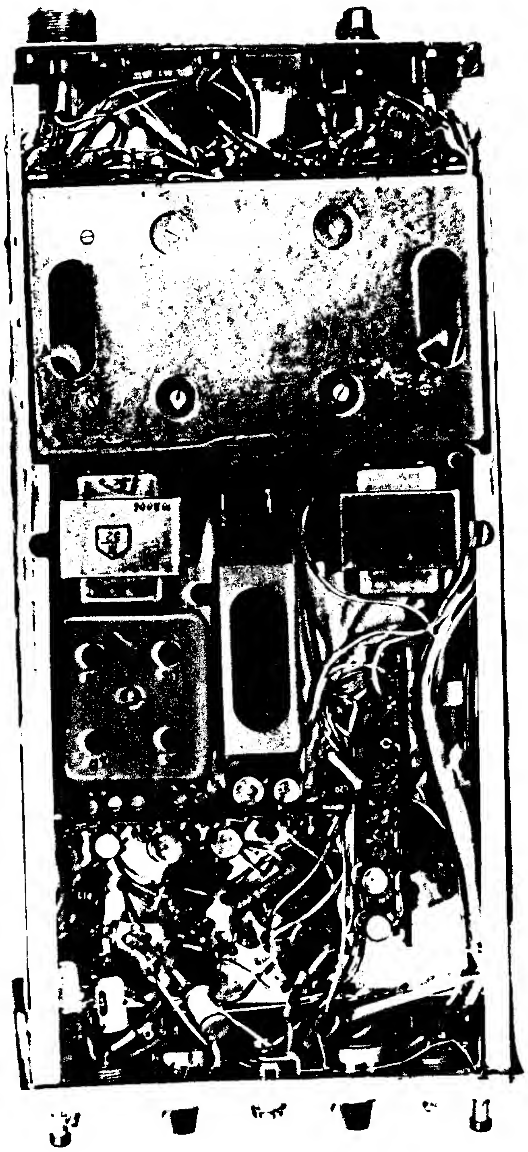


Fig.8. Bottom view of Synchroscope with case removed.

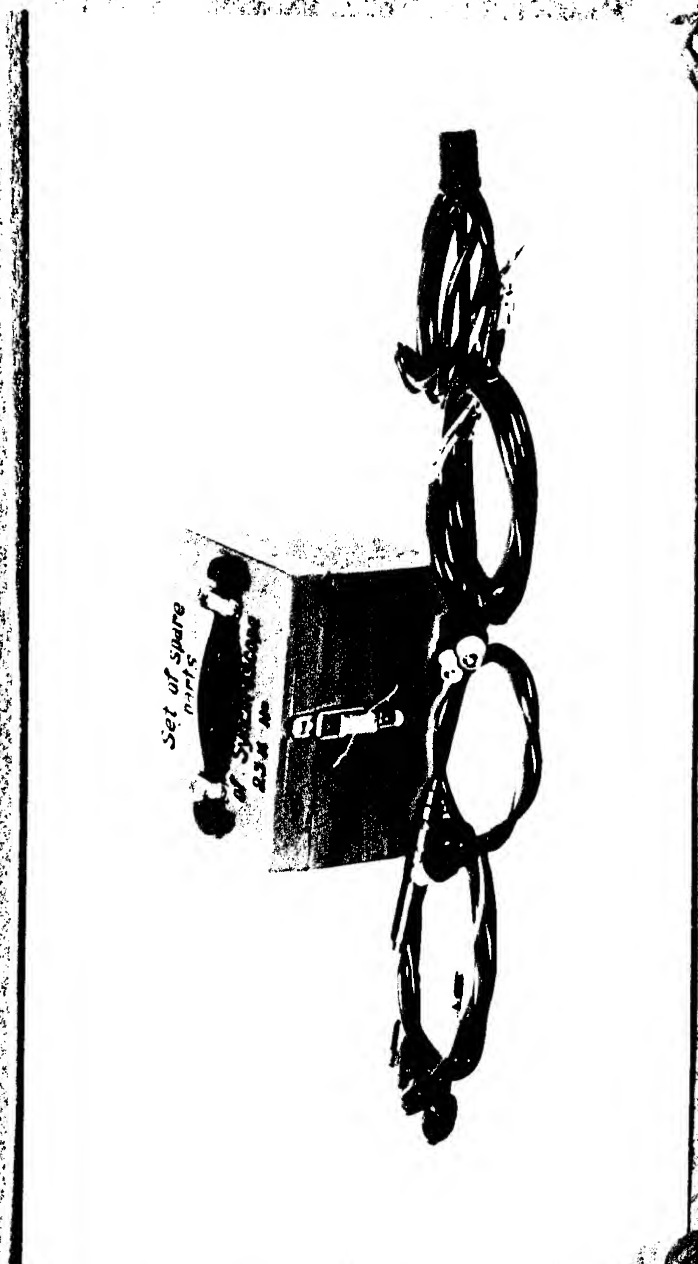



Fig.9. Spare parts and cables.

B. The Design of the External Divider

The external divider is a connecting cable, with a coaxial plug for connecting it to the input jack of the Synchroscope, at one end, and an ebonite tube, with divider elements (resistor R1 and condenser C1) and two alligator clips, for connection to the object under test, at the other end. One clip is attached rigidly to the ebonite tube, while the other, which serves for grounding, is attached to a flexible conductor.

The length of the cable between the ebonite tube and the coaxial plug is equal to 800 mm.

C. The Design of the Connecting Cables

As has already been mentioned the Synchroscope is furnished with two types of cables. Connecting cables of the first type are PK-49 coaxial cables 1.5 metres long with a coaxial plug on one end, for connection to the input or the "Synchronization" jacks of the synchroscope, and alligator clips, for connection to the object under test, at the other end.

The connecting cables of the second type differ from the first in that instead of alligator clips they are fitted with coaxial connectors for connecting the Synchroscope rigidly to the object under test, if the latter is provided with the corresponding jack.

The general view of the cables and the spare parts is shown in Fig.9.

# PART II

## OPERATION

### 1. Preliminary Inspection of the Synchroscope

Before connecting the Synchroscope to the source of power and before operating it, it is necessary to set the supply-voltage switch in the position corresponding to the supply voltage.

### 2. Controls and their Functions

All the main controls are arranged on the front panel, as shown in Fig.10. All the controls are divided into four groups:

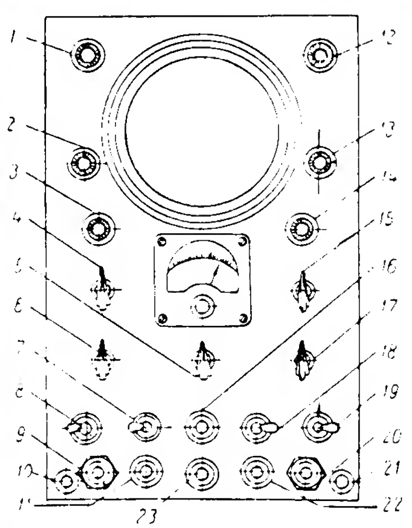



Fig.10. Arrangement of controls on front panel.

1--potentiometer R49 for controlling brightness, and power switch ВК-1; 2--potentiometer R38 for shifting beam vertically; 3--potentiometer R12 for smooth amplification control; 4--switch ПК-2 of second attenuator; 5--sweep switch ПК-8; 6--input attenuator switch ПК-1; 7--amplitude calibrator switch ПК-10; 8--duration calibrator switch ВК-3; 9--signal input jack Г1; 10--ground binding post; 11--calibration signal amplitude control potentiometer R47; 12--focus control potentiometer R51; 13--potentiometer R86 for shifting beam horizontally; 14--smooth amplification control potentiometer R87; 15--smooth sweep frequency control potentiometers R61 and R64; 16--sweep delay control potentiometer R107; 17--switch ПК-5 for rough sweep frequency and speed control; 18--internal-external synchronization switch ПК-6; 19--synchronization signal polarity switch ПК-7; 20--synchronization input jack; 21--ground binding post; 22--synchronization gain control potentiometer R100; 23--pilot lamp.

a) the controls of the cathode ray tube beam; b) the controls for regulating the input signal; c) the controls of the sweeps; d) auxiliary controls.

A. The Controls of the Cathode Ray Tube Beam

1. Brightness is adjusted by means of the potentiometer R49, the knob of which has the inscription "Яркость" (brightness). This control allows the brightness of the spot on the screen of the cathode ray tube to be varied. When operating the Synchroscope it is always best to adjust the brightness so that the greatest definition of the image of the signal under test is obtained.

Note. The power off-on switch is mounted on the same shaft as the brightness-control potentiometer.

The Synchroscope is switched off by turning the "Brightness" knob to the left with a force necessary for the power switch to operate.

2. The focussing of the beam is accomplished by means of the potentiometer R51, the knob of which has the inscription "Фокус" (focus). This control allows the best definition of the image of the signal under test to be set.

3. The beam (or image) is shifted vertically by means of the potentiometer R78, the knob of which has the inscription "Ось Y" (Y axis). When the knob is turned to the right, the image is raised, if the knob is turned to the left, the image is lowered. This control allows the image of the signal under test to be positioned vertically.

4. The beam (or image) is shifted horizontally by means of the potentiometer R66, the knob of which has the inscription "Ось X" (X axis). When the knob is turned to the left, the image moves to the left. When the knob is turned to the right, the image moves to the right.

This control allows the image of the signal under test to be positioned horizontally.

B. The Controls for Regulating the Input Signal

1. The signal under test is applied to the input jack at the lower left-hand corner of the front panel, marked with the inscription "Вход" (input).

2. The input signal is regulated by means of three knobs that are united in one group and have the common inscription "Регулировка входного сигнала" (Input signal adjustment).

a) The switch ПК-1, which has two poles and five positions, (lower knob) provides for the input signal to be attenuated and the input impedance of the Synchroscope to be changed. In the position "75 ОМ" (75 ohms) the input impedance of the Synchroscope is equal to 75 ohms, and the signal is not attenuated. In the position "1:1", the input impedance is equal to 0.51 megohms, and the signal is not attenuated. In the positions "1:10" and "1:100" the signal is attenuated by 10 or 100 respectively, and the input impedance is 0.51 megohms.

The position "калибр" (calibration) is used in cases when the amplitude of the signal under test is to be measured.

b) The switch ПК-2, which has two poles and four positions, (middle knob, marked "Ослабление"--attenuation) provides for the attenuation of the input signal by factors of 2,5 and 10 in accordance with the inscriptions above the knob.

c) The potentiometer R12 (upper knob, marked "Плавная" -- smooth) provides for the smooth regulation of the magnitude of the input signal.

C. The Sweep Controls

The switch ПК-3, which has six poles and four positions, is located under the voltmeter. Its knob has the inscription "Развертка" (Sweep). The switch serves for selecting the type of sweep of the Synchroscope.

The position "Непрерывн." (Repetitive) corresponds to the

switching on of the repetitive (saw-tooth) sweep. The position "Ждущая" (Triggered) corresponds to the triggered sweep. The position "С задержкой" (Delayed) corresponds to the delayed sweep. The position "От сети" (A-C) corresponds to the switching in of an a-c sweep from the a-c main, supplying the Synchroscope.

2. The switch ПК-5, which has six poles and four positions, provides for the selection of the frequency ranges of the repetitive and triggered sweep, in accordance with the inscriptions above the knob.

3. The ganged potentiometers R61 and R64 (knob marked "Частота" -- frequency) change the frequency of the repetitive sweep smoothly within the selected frequency range.

4. The potentiometer R78 (knob marked "Усиление" -- amplification) adjusts the amplitude of the repetitive and a-c sweeps.

5. The potentiometer R107 (knob marked "Задержка развертки" -- sweep delay) varies smoothly the delay of the triggered sweep, from 10 to 100 microseconds, when operating the Synchroscope with a delay triggered sweep.

## D. Auxiliary Controls

The switch ВК-3, marked "Калибровка длительности" (Duration calibration) serves for switching on the negative-resistance oscillator, which generates the calibration markers for measuring the duration of the pulse under test.

2. The switch ПК-10, marked "Калибровка амплитуды" (Amplitude calibration), switches on the calibration signal for measuring the amplitude of the pulse under test.

3. The potentiometer R47, marked "Напряжение" (Voltage), adjusts smoothly the voltage of the calibration signal, which is read on the scale of the voltmeter.

4. The jack Г2, located at the lower right-hand corner and marked "Вход" (Input), serves for connecting the external synchronizing voltage.

5. The switch ПК-6 serves for switching the synchronization and has the markings "Внутрен." and "Внешн." (Internal and External).

6. The switch ПК-7 serves for changing the polarity of the signal fed to the synchronization amplifier and has the markings "+" and "-".

7. The potentiometer R100, marked "Усиление" (Amplification) adjusts the gain of the synchronization amplifier.

In addition to the above-mentioned controls, the following parts are arranged on the front panel:

a) a voltmeter which measures the voltage of the calibration signal;

b) a pilot lamp which indicates that the Synchroscope is switched on;

c) binding posts for grounding the chassis of the Synchroscope.

At the back of the Synchroscope, as has been mentioned, is located a door which gives access to the jacks Г3 and Г4, the switches ПК-3 and ПК-4, and the supply-voltage switch.

The arrangement of the above parts is shown in Figs 10 and 11. The jacks Г3 serve for applying voltage directly to the vertical-deflection plates. The jacks Г4 serve for applying voltage directly to the horizontal-deflection plates.

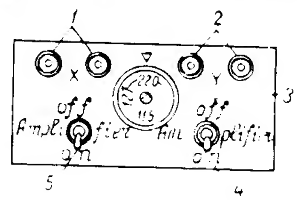



Fig. 11. Arrangement of controls on rear panel.

1--jack Г4 for direct application of voltage to "x" plates; 2--jack Г3 for direct application of voltage to "y" plates; 3--supply-voltage switch ПК-9; 4--switch ПК-3 for disconnecting amplifier from "y" plates; 5--switch ПК-4 for disconnecting amplifier from "x" plates; 6--Off; 7--Amplifier; 8--On.

[illegible]tches ПК-3 and ПК-4 serve for [illegible]

deflection plates from the internal circuit.

The deflection plates are disconnected when the switches are in the upper position.

3. Switching on of the Synchroscope and Operation Procedure

A. Switching on of the Synchroscope and Preliminary Adjustment

In order to switch on the Synchroscope, it is necessary to connect the supply cord to the a-c main and to turn the knob "Яркость" (Brightness) to the right so that the power switch, which is ganged with the potentiometer, which regulates the brightness, is moved out of the position "Выключено" (Off).

After the Synchroscope has warmed up for a minute it is necessary to:

a) Adjust the brightness so that the beam is visible on the screen of the cathode-ray tube. The beam should not be bright, but well seen.

WARNING! The beam should not be left on one spot of the screen as this will cause that spot of the screen to burn out.

b) Adjust the "Focus" control so that the beam is as round and as small as possible.

c) With the aid of the knobs "Ось X" and "Ось Y" (X Position and Y Position) set the beam in the centre of the screen.

After the Synchroscope has been switched on and it has warmed up during 10-15 minutes and the preliminary adjustments have been made, it is ready for operation. The type of operation can now be selected and the necessary observations and measurements performed.

B. Selecting the Type of Operation

When selecting the type of operation it is necessary to de-

termine: the type of sweep, the sweep speed (frequency), the input impedance, the source of the synchronization voltage, the type of connection to the object under test (directly to the input of the Synchroscope or through the external divider).

The selection is usually determined by the character and magnitude of the voltage under test and the peculiarities of the circuit under test. If certain of these conditions are not known, or if all of them are not known, then it is necessary to determine the type of operation best suited for investigating the given unknown voltage by means of a series of trials.

Below are listed the general considerations which should be taken into account when selecting the type of operation.

a) Type of Sweep

When selecting the type of sweep it should be borne in mind that the repetitive sweep serves for observing periodical sinusoidal voltages, while the triggered sweep serves for observing pulses.

The repetitive sweep is provided with continuous frequency adjustment ranging from 10 to 100,000 c.p.s.; the triggered sweep has four fixed values of duration: 2, 10, 50, and 250 microseconds.

The type of sweep is selected by means of switch ПК-8, the knob of which is located on the front panel and is marked with the inscription "Развертка" (Sweep).

b) Sweep Speed (Frequency)

The speed of the sweep should be selected so, that the shape of the voltage pulse or the wave under test is well seen. The image should be spread horizontally and should occupy the greater part of the screen.

If the duration of the pulse under test is known, then it

is possible to set the speed switch to the required speed beforehand, in accordance with the inscriptions on the front panel. When using the repetitive sweep the sweep-speed switch selects only the frequency range. Exact adjustment of the sweep frequency is made with the aid of the frequency-control knob (marked "[illegible]" — Frequency), while observing the screen of the cathode ray tube.

If the duration of the pulse under test is totally unknown, then one of the medium speeds (10 or 50 microseconds) should be selected as a point of departure.

d) Input Impedance

When measuring the voltage across the output of a line or the output of an equipment, having a low output impedance, it is necessary to set the switch ПК-1 of the input attenuator in the position "75 ohms".

If the switch of the input attenuator is set in the position "75 ohms", the voltage across the input of the Synchroscope should not exceed ±1 volt, to avoid overloading the signal amplifier. In order to obtain a sufficient amplitude of the image, the input voltage should not be less than 0.1 volt.

If the switch of the input attenuator is set in the position "75 ohms", but the circuit under test has a greater output impedance, the amplitude of the pulse image will decrease and its shape will be distorted.

If the output impedance of the circuit under test is high, the switch of the input attenuator should be set in the positions: 1:1; 1:10 or 1:100. In this case, the input impedance of the Synchroscope is equal to 0.51 megohms. With a high input impedance it is possible to select three sensitivity ranges, depending on the attenuation that is set with the switch.

In the position "1:1" of the switch, the sensitivity is the greatest, and the voltage across the input should range from 0.1 to 1 volt.

In the position "1:10" the sensitivity is medium, and the voltage across the input should range from 1 to 10 volts.

In the position "1:100", the sensitivity is the least, and the voltage across the input should range from 10 to 100 volts.

Note. The indicated voltage limits determine the positive and negative deflections from an average value, consequently a symmetrical a-c voltage, as measured from peak to peak, can be twice the indicated values.

The voltage across the input of the Synchroscope should not exceed greatly the above-indicated maximum values. When preparing the Synchroscope for the investigation of unknown voltages, it is always necessary to set the switch of the input attenuator in the position "1:100", after which it can be re-set, while the image on the screen is observed.

When investigating high voltages without the external divider, the switch should never be set in the position "75 ohms" as this may cause the 75-ohm resistance at the input of the Synchroscope to burn out.

In order to obtain an input impedance greater than 0.51 megohms it is necessary to connect the external divider between the source of the voltage and the input of the Synchroscope.

The input impedance of the external divider is approximately 5 megohms with a capacitance of 12-15 mmf connected in parallel. The external divider attenuates the voltage applied to the input of the Synchroscope by approximately 10 times.

The smallest voltage that can be measured, with the external divider connected, is not less than 1 volt.

the maximum peak voltage applied to the external divider should not exceed 500 volts.

WARNING! Such voltages are dangerous to life. When making connections to an equipment, having such voltages, it is first necessary to switch the equipment off.

d) Synchronizing-voltage Source

In most cases, it is most convenient to synchronize the sweep with the pulses of the signal under test. In order to do this the synchronization switch is set in the position "Внутр." (Internal). If the signal under test has an irregular shape or if it is desirable to start the sweep with a pulse which leads the signal, then it is necessary to connect the source of synchronizing pulses to the external synchronization jack located at the right of the front panel, and to set the synchronization switch in the position "Внешн." (External).

## C. Using the Synchroscope for Various Types of Operation

a) Triggered Sweep Synchronized with the Signal under Test

In order to operate with the triggered sweep synchronized with the signal under test, it is necessary to perform the following manipulations:

1. Set the switch "Развертка" (Sweep) to position "Ждущая" (Triggered).

2. Set the synchronization switch to position "Внутр." (Internal).

3. Set the sweep speed switch ПК-5 to the position which corresponds to the duration of the signal under test.

4. Set the switch of the second attenuator to the position "1:1".

5. Turn the knob "Плавно" (Smooth) counter-clockwise to the position corresponding to the minimum amplitude of the image.

6. Set the input attenuator to the position corresponding to the output impedance and voltage of the circuit under test.

When operating with the external divider, the input attenuator should not be in the low-ohm position "75 ohms".

7. Apply the signal to be investigated to the jack "Input", located at the left-hand side of the front panel of the Synchroscope.

8. Set the knob "Усиление" (Amplification) which controls the synchronization voltage, in the extreme right position.

9. Select the correct position of the synchronization-polarity switch.

When the polarity of the signal under test is known, set the switch in position "+" for negative polarity and position "-" for positive polarity.

After the above operations have been performed, the image of the signal under test should appear on the screen of the cathode ray tube.

If instead of the image of the pulse, only the sweep line is seen, then select the corresponding position of the attenuator and the gain control of the vertical-deflection amplifier. When the amplitude of the signal under test is small, the sweep will not be started. This is indicated by the absence of the sweep line on the screen.

10. After the image is obtained on the screen, the necessary brightness and definition of the image is adjusted by means of the knobs "Brightness" and "Focus".

11. A full image, covering the whole width of the screen, is obtained by selecting the correct position of the sweep-speed switch.

12. The image is centered on the screen with the aid of the horizontal and vertical beam-positioning knobs.

The image is considered correctly positioned when the front edge of the pulse lies in the middle of the left side of the screen, and the horizontal or sweep line passes through the centre of the screen.

13. In order to avoid distorting the image of the signal under test by overloading the vertical-deflection amplifier, the image of the pulse should not extend more than 30 mm vertically, while the images of sinusoidal voltages should not extend more than 60 mm vertically.

b) <u>Repetitive Sweep Synchronized by the Signal under Test</u>

The procedure is the same as for triggered-sweep operation, except that it is necessary to:

1. Set the sweep switch in the position "Непрерывн." (Repetitive).

2. Adjust the synchronization voltage by means of the knob "Усиление" (Amplification), so that the necessary synchronization and image stability are obtained.

3. Set the synchronization polarity switch in the position "+" which gives a slightly greater gain of the synchronization amplifier.

If the amplitude of the voltage under test is great, this need not be observed, as the repetitive sweep does not require a definite polarity.

4. Set the sweep-speed switch in the position corresponding to the required sweep frequency and adjust the frequency exactly with the aid of the knob marked "Частота" (Frequency).

<u>Note</u>. When using the repetitive sweep oscillator for obtaining a stationary image, the frequency of the oscillator has to be

equal to or a multiple of the frequency of the signal under test. If this does not obtain, stable, synchronized operation will not be ensured, and the image will be blurred and instable.

c) Sweep Synchronized by an External Source

In order to synchronize the sweep with an external source, it is necessary to connect the external synchronization source to the jack "Вход" (Input) located on the right-hand side of the front panel of the synchroscope, and to set the synchronization switch in the position "Внешн." (External). The setting of the other controls and further adjustments are made in the same way as has been described for sweeps synchronized by the signal under test.

When synchronizing with an external source, it is possible to use either the triggered or the repetitive sweep.

The external synchronization voltage should range from 5 to 50 volts for the triggered sweep, and from 2 to 20 volts for the repetitive sweep.

If the external synchronization source gives too great a voltage, then in order to avoid distorting the image it is necessary to decrease the synchronization voltage by turning the knob (marked "Amplification") of the synchronization amplifier gain control in the counter-clockwise direction. If the decrease in voltage obtained with the aid of this knob is not sufficient, it is necessary to use an external voltage divider.

When starting the triggered-sweep oscillator from an external synchronization source, the synchronization-polarity switch should be set in the position corresponding to the polarity of the starting pulse.

If the starting pulse is positive, the polarity switch

should be set in the position "+". If the starting pulse is negative, the polarity switch should be set in the position "-".

d) Delayed Triggered Sweep

In order to obtain a triggered sweep which is delayed with respect to the external starting pulse, it is necessary to:

1. Set the sweep switch in the position "Q задержкой" (Delayed).

2. Set the synchronization switch in position "Внешн." (External).

3. Apply the synchronization voltage from the external source to the input jack on the right-hand side of the front panel of the synchroscope.

The polarity switch should be set in the corresponding position as indicated for the case of starting the triggered sweep from an external pulse source, and the synchronization voltage is selected to ensure stable operation of the circuit.

4. The necessary time delay is obtained with the aid of the knob marked "Задержка" (Sweep delay). By turning this knob it is possible to set any desired sweep delay ranging from 10 to 100 microseconds.

Note. When adjusting the delay value, it is best to adjust, somewhat, the synchronization amplifier gain at the same time. With a decrease in gain, the delay limits are extended. With an increase in gain, the delay limits are narrowed. By using the controls "Sweep delay" and "Amplification" it is always possible to obtain the necessary delay value and stable operation of the circuit.

5. The setting of the other controls and further adjustments are made in the same way as has been described for sweeps synchronized by the signal under test.

### c) Sweeping with the A-C Voltage, Supplying the Synchroscope

In order to obtain an a-c sweep from the main supplying the Synchroscope, it is necessary:

1. Set the sweep switch in the position "От сети " (A.C.).
2. Adjust the horizontal gain, using the knob marked "Уси-ление " (Amplification).

It is convenient to use this type of sweep when it is desirable to obtain Lissajous figures on the screen of the cathode ray tube, for comparing low frequency oscillations.

If the exact sweep frequency is known, i.e. if the frequency of the supply main is known, then by applying periodic voltages of various frequencies to the input of the Synchroscope, it is possible to determine, with the aid of the figures, those frequencies that are multiples of the mains frequency.

In cases of exact coincidence in frequency, the figures obtained with the sinusoidal sweep will be stationary.

## D. Determining Sweep and Pulse Durations

The durations of pulses and sweeps are determined by superimposing calibration markers on the sweep line or the image of the pulse under test.

The calibration markers are generated by the negative-resistance oscillator and are switched on by setting the calibration-duration switch in the "On" position.

### a) Determining Sweep Duration

In order to determine the duration of the sweep it is necessary to:

1. Set the sweep switch in the "Delayed" position.
2. Set the sweep speed switch in the position corresponding to the required sweep speed.

3. Apply the pulse for starting the triggered sweep to the synchronization input.

4. Adjust the synchronization gain so that a stable sweep line is obtained on the screen of the cathode ray tube.

5. Position with the aid of knobs "Oos X" (X position) and "Qos Y" (Y position) the sweep on the screen.

6. With the aid of the calibration-duration switch, switch on the calibration markers, which should now appear on the sweep line in the shape of bright knots with dark spaces between them. The sweep line now somewhat resembles a dotted line.

7. After applying the calibration markers to the sweep line, it is necessary with the aid of the knobs "Focus" and "Brightness" to adjust the brightness and focus so that the sweep line with the superimposed markers is seen as clearly as possible.

8. By counting the number of markers there are on the sweep line, it is easy to determine the duration of the sweep.

It should be borne in mind that when the speed switch is in the position "250 microseconds" the distance between the markers will be equal to 10 microseconds, when it is in position "50 microseconds" to 2 microseconds, in the position "10 microseconds" to 0.5 microseconds, and in the position "2 microseconds" to 0.1 microseconds.

b) Determining Pulse Durations

When determining the durations of pulses, the manipulations remain the same as in paragraph "a". It is only first necessary to obtain the image of the pulse under test on the screen of the tube, and then to superimpose the calibration markers.

The values of the markers for the various ranges are the following:

1st range ...................... 10 microseconds

2nd range ...................... 2 microseconds

3rd range ...................... 0.5 microseconds

4th range ...................... 0.1 microseconds

The number of markers superimposed on the pulse are counted (one bright spot and one dark space are counted as one marker). The product of the number of markers multiplied by the value of one marker gives the duration of the pulse.

The accuracy of determining pulse duration will be the greater, the nearer the duration of the pulse is to the duration of the sweep. Thus, for example, for a speed of 2 microseconds and a pulse of the same duration, the pulse will be "expanded" across the whole screen of the tube, and 20 calibration markers of 0.1 microseconds each will be seen on it. Given that we can count with an accuracy of half a marker, i.e. that it is possible to take a reading within 0.05 microseconds, then we will have the following relative accuracy $\frac{0.05}{2}\,100 = 2.5\%$

c) Determining Pulse Amplitudes

In order to measure the amplitude of the pulse under test, it is necessary to:

1. Apply the pulse to the input of the Synchroscope.

2. With the aid of the input signal controls, adjust the required size of the pulse on the screen of the tube.

3. Note the size of the pulse image with the aid of the net in front of the screen of the tube.

4. Note the position of the switch of the input attenuator.

5. Set the switch of the input attenuator in the position "Калиб." (calibration).

6. Set the switch "Калибровка амплитуды" (Amplitude calibration) in the position "Вкл." (On).

7. With the aid of the knob "Напряжение" (Voltage), adjust the voltage of the calibration signal so that it is equal to the image of the signal under test, when measuring the amplitude of periodic processes or to double the image of the signal under test when measuring the amplitude of one-sided pulses.

8. Take the reading of the voltmeter.

9. Divide the reading by 100 for an attenuator position of "75 ohms" or "1:1", by 10 for position "1:10", and by 1 for position "1:100".

The scale of the voltmeter is calibrated in amplitude values, therefore when measuring pulse amplitudes it is not necessary to make any calculations.

Example: Let us suppose that a voltage pulse of an unknown amplitude is applied to the input of the Synchroscope. Suppose that in order to get an image of the voltage pulse on the screen of the required size, it was necessary to set the switch of the input attenuator in the position "1:10". After adjustment, with the aid of the knobs "Ослабление" (Attenuation) and "Плавно" (Smooth), the size of the image was set at 20 mm (according to the net on the screen).

After switching on the calibration signal, the size of its image was adjusted to correspond to 20x2=40 mm. The voltmeter reading was 78 volts. Consequently the magnitude of the amplitude of the pulse under test is equal to 78:10=7.8 volts.

Note. In the intervals between the switching on of the known and the unknown voltages, the positions of the knobs "Attenuation and "Smooth" should not be changed, by any means.

If the signal to be measured is applied to the input of the Synchroscope through the external divider, it is possible to measure the voltage of signals exceeding 100 volts. The result

obtained in this case must be multiplied by 10.

The general procedure for measuring voltage remains the same as when the signal is applied directly to the input.

d) Applying Voltage Directly to the Deflection Plates

The circuit and design of the Synchroscope provides for the application of voltages directly to the horizontal and vertical deflection plates. For this it is necessary to open the door on the back wall of the case, and to apply the voltages to the jacks arranged on the rear panel.

The left-hand pair of jacks (looking through the door) serves for applying voltage to the horizontal plates, the right-hand pair for applying voltage to the vertical plates.

When applying voltage directly to the plates, it is necessary to set the switches located under the jacks in the upper position. In this case the deflection plates are disconnected from the amplifier circuits.

The application of pulses under test directly to the vertical deflection plates is possible when the amplitudes of the latter are sufficient (amplitude exceeds 20 volts).

It is not recommended to apply voltages in excess of 200 volts directly to the plates, as in this case the image will over-reach the limits of the screen. When applying the pulse under test directly to the vertical deflection plates, it should be borne in mind that, in this case, the internal synchronization channel will not operate, and, consequently, for synchronizing and starting the triggered sweep, it will be necessary to apply the synchronizing or starting voltage to the synchronization input, and to set the synchronization switch in the position "ВНЕШ." (external). The synchronizing or starting voltage should be taken from some point of the circuit under test which can give a voltage

pulse of the required amplitude and frequency.

It should also be borne in mind that in this case the delay of the signal channel will not function, and, therefore, the front edge of the signal under test may not be visible. If it is desirable to apply an external sweep voltage to the horizontal plates, this external voltage must be applied to the jacks as indicated above. In addition, it is necessary to eliminate the generation of sweep pulses. This is done by setting the sweep switch in the position "Delayed", and the synchronization switch in the position "External".

e) Safeguards against Electric Shock

1. If the case of the Synchroscope is in place, the operator is protected from the dangerous high voltages which obtain inside the instrument. Operation of the Synchroscope with a removed case is not allowed.

2. The use of the Synchroscope for investigating high-voltage pulses should be conducted only by skilled operators, well acquainted with the circuits to be investigated.

The connection of the Synchroscope to high-voltage equipment should be performed only with the supply voltages disconnected.

## PART III.

## DESCRIPTION OF THE OPERATION OF CIRCUIT UNITS

### 1. The Signal Channel

The signal channel of the Synchroscope is designed chiefly for amplifying the signals under test and also for delaying these signals so that the sweep channel would start the horizontal deflection of the beam before the signal pulse is applied to the vertical deflection plates of the cathode ray tube.

The signal channel consists of the input, decade, stepped

attenuator, the cathode repeater, the delay line, the second stepped attenuator, the gain control potentiometer, and the three-stage amplifier.

A. The Input Attenuator

The input of the attenuator is connected to the input jack Г1. The attenuator consists of the switch ПК-1, which has two poles and five positions, and the corresponding resistors and condensers.

In the first position of the switch, the 75-ohm resistor R2 is connected in parallel with the input of the Synchroscope. It is designed for matching the input of the Synchroscope with low-ohm outputs of circuits to be investigated, and is usually used for circuits having an output impedance from approximately 60 to 90 ohms. The other positions of the switch correspond to a high-ohm input (0.51 megohms) and are used for circuits having high output impedance.

In the three positions of the switch which correspond to a high-ohm input, the attenuator functions as an attenuator with three different division factors and a constant total impedance. The input dividers consist of the resistors and condensers R4, C4 and R6, C6 in the position 1:10 and, respectively, of R5, C7 and R7, C8 in the position 1:100. The use of condensers in the attenuator is called forth by the need of ensuring a wide-band response. The exact alignment of the attenuator is achieved by the condenser C3 for position 1:10, and C5 for the position 1:100.

In the position 1:1, in parallel with the input, is connected the resistor R3 which together with the condenser C2 forms an arm of the attenuator when the external divider is used. The second arm of the attenuator is located in the probe

of the external divider (R1, C1). The values of the input impedance, the attenuation factors, and the values of the input voltages are given in table 1.

Table 1.

| Switch position | Input impedance | | Voltage ratio | | Voltage across input, V | | | |
|---|---|---|---|---|---|---|---|---|
| | without extern. divider | with extern. divider | $\frac{V_o}{V_g}$ | $\frac{V_p}{V_g}$ | without ext. divider | | with ext. divider | |
| | | | | | min. | max. | min. | max. |
| 1 | 75 ohms | 5 megohms | 1 | 10 | 0.1 | 1 | — | — |
| 2 | 0.51 megohms | 5 " | 1 | 10 | 0.1 | 1 | 1 | 10 |
| 3 | 0.51 " | 5 " | 10 | 100 | 1 | 10 | 10 | 100 |
| 4 | 0.51 " | 5 " | 100 | 1000 | 10 | 100 | 100 | 500 |

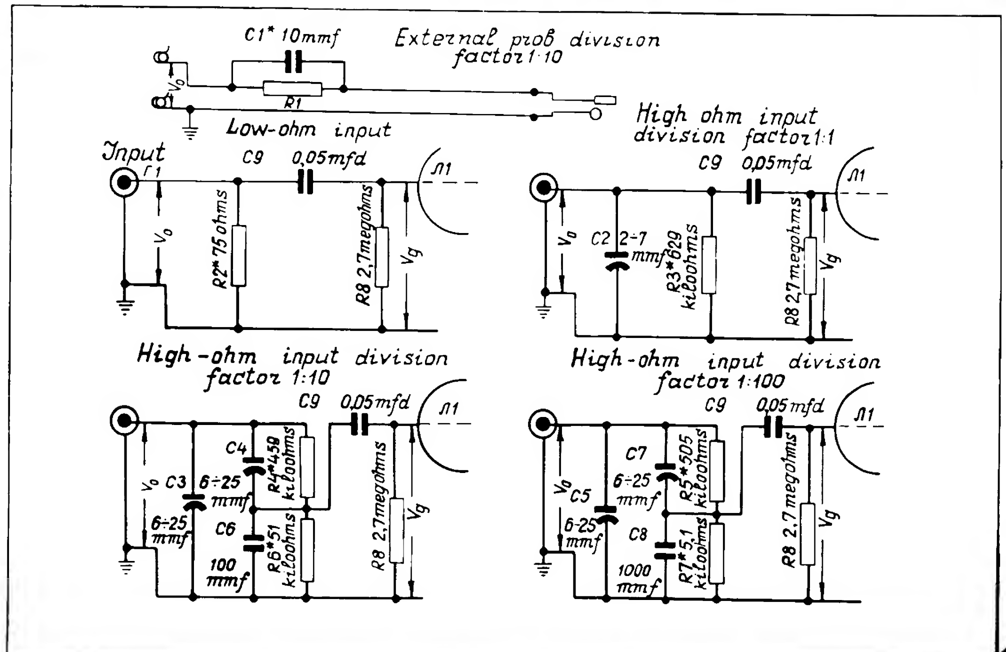
where $V_o$ - Voltage across Synchroscope input without external divider;

$V_p$ - Voltage across Synchroscope input with external divider;

$V_g$ - Voltage on grid of first valve.

The above table shows that, depending on the position of the switch, the input impedance can be 75 ohms and 0.51 megohms, with attenuation factors of 1:1, 1:10, 1:100 (and input voltages from 0.1 to 100 volts).

When using the external divider which has an attenuation factor of 1:10, the input impedance increases to 5 megohms, and the input voltage may be increased to 500 volts. The functioning of the input attenuator and the external divider is explained by the diagrams in Fig.12.



External prob division factor 1:10
C1* 10mmf
R1
Low-ohm input
Input
C9 0,05mfd
R2* 75 ohms
R8 2,7 megohms
High ohm input division factor 1:1
C2 2÷7 mmf
R3* 629 kiloohms
High-ohm input division factor 1:10
C3 6÷25 mmf
C4 6÷25 mmf
R4* 459 kiloohms
C6 100 mmf
R6* 51 kiloohms
High-ohm input division factor 1:100
C5 6÷25 mmf
C7 6÷25 mmf
R5* 505 kiloohms
C8 1000 mmf
R7* 5,1 kiloohms

## B. The Cathode Repeater

The output of the input attenuator, through the coupling condenser C9, is connected to the input of the cathode repeater (valve Л1).

The use of a cathode repeater is conditioned by the need of matching the high input impedance of the Synchroscope with the low input impedance of the delay line and the second attenuator. Due to the use of a high negative-feedback factor, in the cathode repeater, the input signal is repeated by the valve without distortion but with an amplification which is always less than unity.

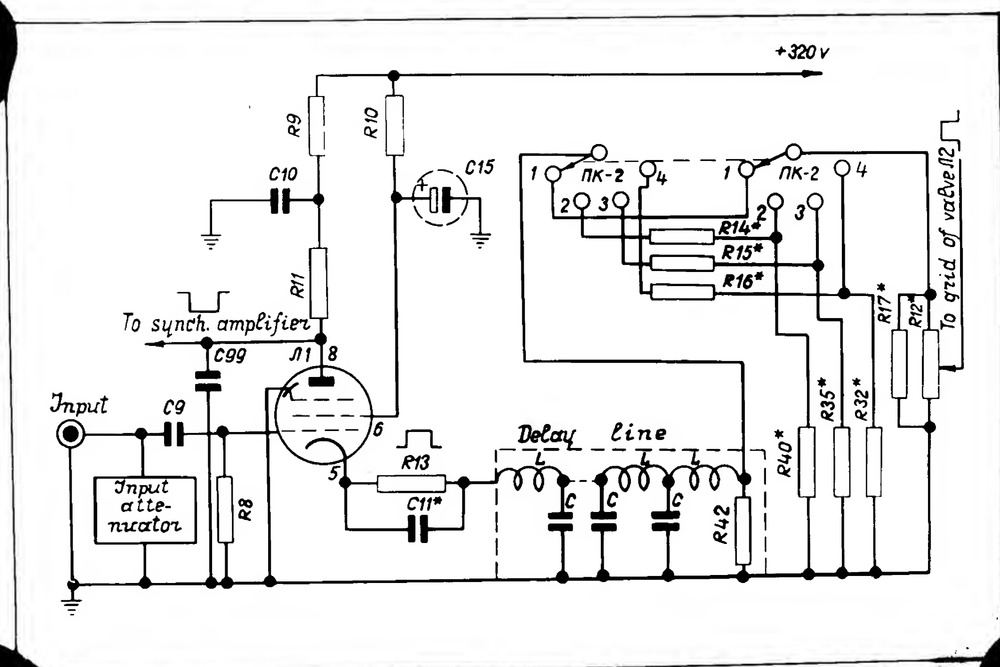
The cathode load of the Л1 valve consists of the series resistor R13, the delay line, and the second attenuator.

Voltage is fed to the plate of the cathode repeater through the decoupling circuit [illegible], C10. The resistor R11 serves as a plate load for tapping off the synchronizing signal for internal synchronization. The screen grid is supplied through the dropping resistor R10 which is simultaneously the dropping resistor for feeding the screen grids of the valves Л2 and Л3. In order to preclude parasitic oscillations on high frequencies, the resistor [illegible] is inserted in the grid circuit of the valve Л1. The resistor R8 serves as the grid resistor.

The condenser C11 is connected in parallel with the resistor R13 for correcting the frequency response.

## C. The Delay Line

The delay line (Fig.13), connected to the cathode of the Л1 valve, is designed for delaying (without noticeable distortion) the signal by 0.3 ±0.1 microseconds. This is necessary in order to observe the image of the front edge of the pulse under test on the screen of the tube. The line consists of [illegible] inductance sections L, connected in series, and by-passed by the condenser.

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The inductance of each section is equal to about 14 microhenry. The capacitance of each condenser is equal to about 40 mmf. On the whole the delay line is similar to a transmission line with uniformly distributed constants up to a frequency of 15 mc. The wave impedance of the line is approximately 550 ohms.

### D. The Second Attenuator and the Smooth Gain Control

The signal delay line (see Fig.15) is loaded by the second attenuator, the impedance of which is equal to 600 ohms, and is adjusted to match the wave impedance of the line, with the aid of resistor R42.

The second attenuator adjusts the input voltage applied to the grid of valve Л2 of the vertical deflection amplifier. Because of the low value of the resistors, comprising the attenuator (R40, R14, R15, R35 and R16, R32), capacitances are not required for correcting high frequency response. In other respects, the second attenuator functions similarly to the input attenuator.

The voltage is regulated with the aid of the four-position wafer-type switch ПК-2.

The attenuator has the following division factors: 1:1, 1:2, 1:5, and 1:10. Smooth adjustment is made by means of the potentiometer R12, which is shunted by the resistor R17 for better matching with the output impedance of the second attenuator.

### E. The Vertical-deflection Amplifier

The slider of the smooth gain control R12 is connected to the grid of the first valve (Л2) of the vertical-deflection amplifier through the coupling condenser C12. The resistor R18 serves as the grid resistor of the valve. Bias voltage for the grid

is provided by the voltage drop, caused by the d-c component of the plate current across the resistor R19, which has the condenser C13 connected in parallel for by-passing the a-c components. Output voltage for the next stage is taken from the plate of the valve. The plate circuit includes the following: the load resistor R22, the high-frequency correction circuit consisting of L2 and R21, and the low-frequency correction filter, consisting of R20 and C20, which serves simultaneously for de-coupling the plate supply of valve Л3.

The second stage of the vertical-deflection amplifier (valve Л3) is similar to the first stage.

The output amplifier (valves Л4 and Л5) operates in a paraphase circuit.

This amplifier not only amplifies the incoming signal, but converts the unbalanced input voltage into a balanced (push-pull) output voltage.

The working principle of such an amplifier, as is well known, consists in the following: when a positive pulse is applied to the grid of valve Л4, a considerable current starts to flow through the valve, causing the plate voltage to fall and the voltage drop across the resistor R41 to increase. The valves Л4 and Л5 have a common cathode load, therefore the increase voltage drop across resistor R41 increases the negative bias on the grid of valve Л5, which in its turn increases the plate potential of this valve. Thus two considerable voltages are developed on the plates of the valves Л4 and Л5, which differ in phase by 180°. These voltages are applied to the vertical deflection plates of the cathode ray tube and deflect the electronic beam in the vertical direction.

In the described Synchroscope, the beam is positioned with the aid of the potentiometer R38, which controls the voltage on

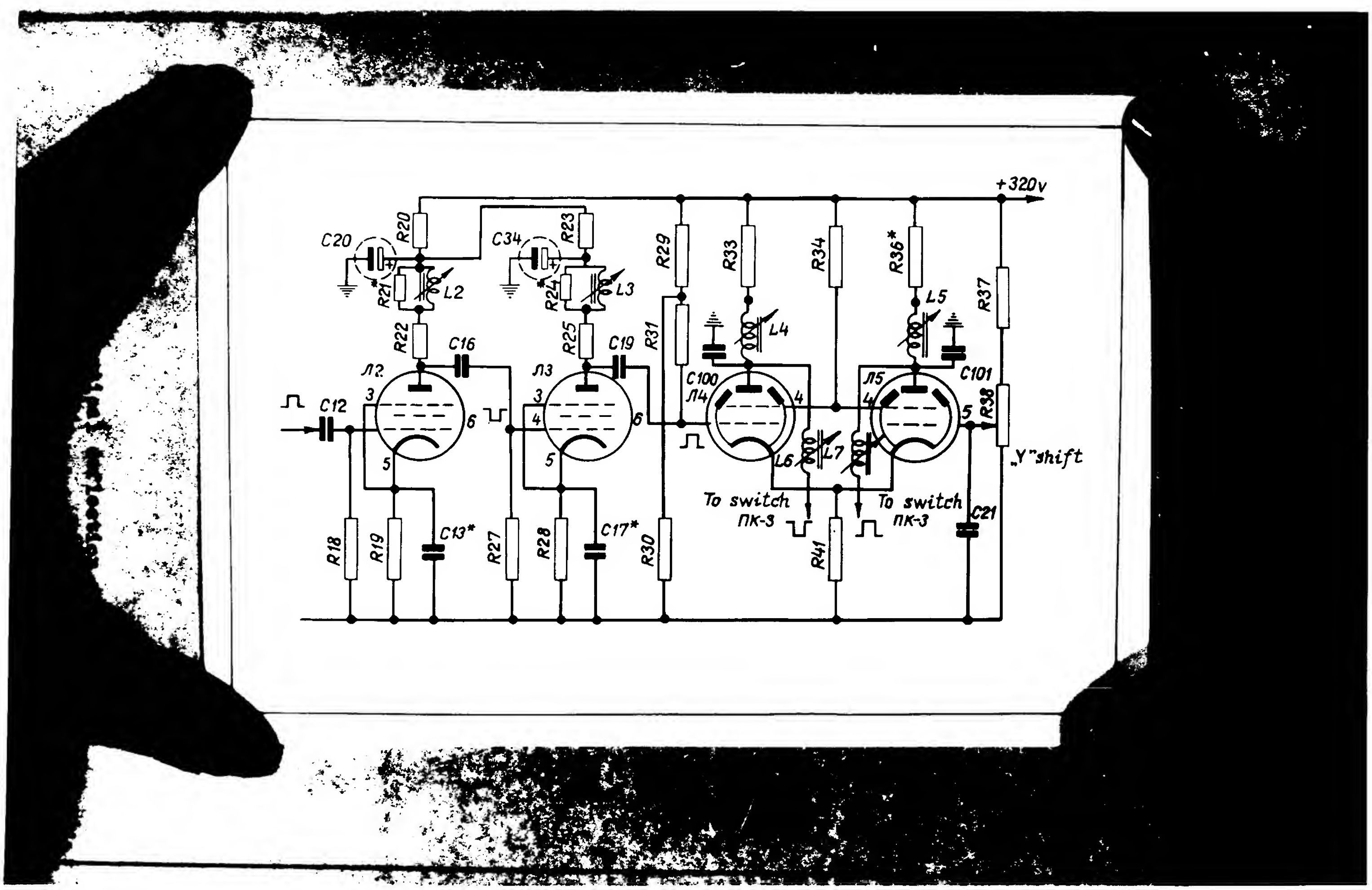
the grid of the valve Л5. A change in the voltage on the grid of this valve causes the plate potential of one valve to fall and the plate potential of the other valve to rise. This shifts the light spot on the screen of the tube.

High-frequency correction in this amplifier is achieved with the aid of the inductances L4, L6 and L5, L7 together with the condensers C100, C101. Since the voltage drop caused by the d-c component across the resistor R41 creates a large negative bias on the valve grids, operation on the linear section of the valve characteristics is provided for by feeding a positive bias to the grids, from the divider R29, R30 and R31 for valve Л4, and R37, R38 for valve Л5. The screen grids of the valves Л4 and Л5 are supplied through the dropping resistor R34. The complete circuit diagram of the vertical deflection amplifier is shown in Fig.14, the frequency response curve is given in Fig.15.

## 2. The Synchronization and Sweep Channel

The synchronization and sweep channel is designed for deflecting the electronic beam horizontally, in synchronism with the pulse under test. The input of the channel is provided with a switch ( ПК-6) which makes it possible to synchronize the sweep with either the signal under test or with an external source.

The synchronization and sweep channel includes the polarity switch ( ПК-7), the synchronization amplifier, three sweep systems (repetitive, triggered, a-c), the horizontal deflection amplifier, and the sweep delay.

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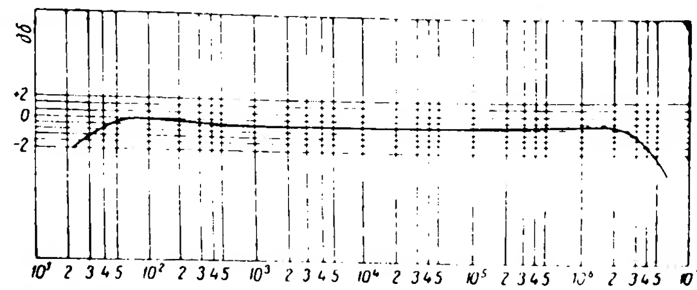



**Fig.15. Frequency response.**

A. <u>The Synchronization Amplifier and the Polarity Switch</u>

The circuit diagram of the synchronization amplifier is shown in Fig.16. If the synchronization switch (ПК-6) is set in the position "Internal", then the synchronization pulses from the signal channel are applied through the switch ПК-7 to one

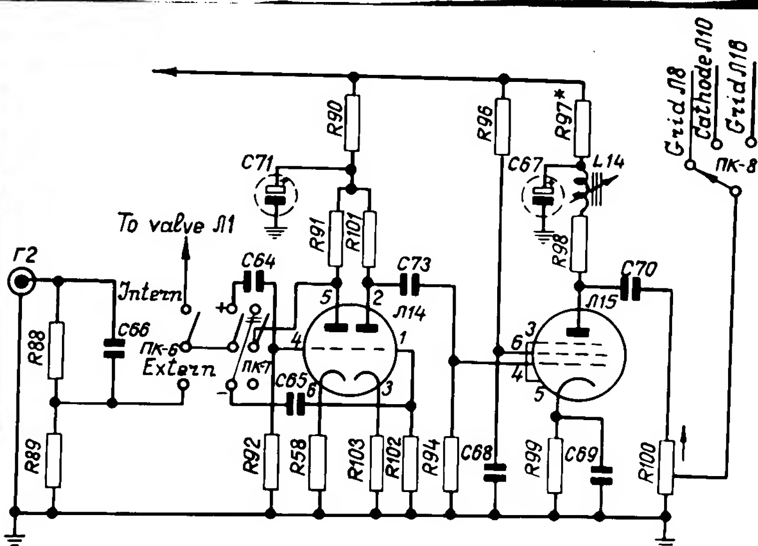



Fig.16. Synchronization amplifier and polarity switch.

of the grids of the valve Л14. When the synchronization pulse is negative, then it passes through the condenser C65 to the grid of the right triode of the valve Л14, is amplified by this valve, and from the plate resistor R101 through the condenser C73 is im-

pressed on the grid of the valve Л15. When the synchronization pulse is positive, then it passes through the polarity switch ПК-7 and the condenser C64 to the grid of the left triode of valve Л14, is inverted by the valve, and is again impressed on the grid of the right triode of the valve Л14, having now a negative sign. Thus the switch ПК-7 and the left half of valve Л14, serve for changing the polarity of the synchronization pulse.

This is necessary as the pulse starting the triggered sweep must always be negative. When the repetitive sweep is operating and is synchronized by an a-c current of a certain frequency, the position of the switch ПК-7 is immaterial.

The repetitive sweep will be sufficiently synchronized regardless of the position of the switch ПК-7.

If the switch ПК-6 is set in the position "Внешн." (External), the synchronization signal from the external source is fed to the voltage divider consisting of the resistor R88 and R89 (division factor approximately 10). This makes it possible to apply voltages of up to 50 to the synchronization input (jack Г2). Next, the synchronization signal passes through the polarity switch ПК-7 which is set according to the polarity of the signal.

The signal impressed on the grid of the valve Л15, as has been indicated above, is always positive, therefore the pulse taken from the plate load of the valve Л15 is always negative, which is necessary for starting the triggered sweep.

The valve Л15 is the main valve of the synchronization amplifier. The voltage, applied to the grid of this valve, is amplified by it, and, from the plate load R98, passes through the condenser C70 to the potentiometer R100, from where by way of the sweep switch ПК-8 it is fed to the repetitive sweep circuit, the triggered sweep circuit, or the sweep delay circuit.

Position "1" of the switch ΠK-8 corresponds to the repetitive sweep, the position "2" to the triggered sweep, the position "3" to the delayed triggered sweep, and position "4" to the a-c mains sweep (in the latter case the synchronization amplifier is disconnected).

The variable resistor R100 serves for regulating the magnitude of the voltage of the synchronization signal. The knob of this resistor is located on the front panel and is marked with the inscription "Усиление " (Amplification).

The coil L14 in the plate circuit of the valve serves for correcting the high-frequency response. The de-coupling circuit R97 and C67 serves for ensuring stable operation of the Л15 valve, which has a tendency to oscillate due to coupling through the common supply source.

B. Sweep Delay (Fig.17)

If the sweep switch ΠK-8 is set in the third position, the triggered sweep operates with a time delay. In this case the synchronization, voltage pulse from the potentiometer R100 is fed to the grid of the valve Л16.

The valve Л16 functions as a cut-off unbalanced multivibrator, which is opened by the synchronization pulse and generates practically rectangular pulses of a long duration. The duration of these pulses is varied by changing the operation characteristics of the multivibrator with the aid of the variable resistor R107.

The knob of this resistor is located on the front panel and is marked with the inscription "Задержка развертки " (Sweep delay). By changing the duration of the pulse from 10 to 100 microseconds, we change the sweep delay time by approximately the same amount.

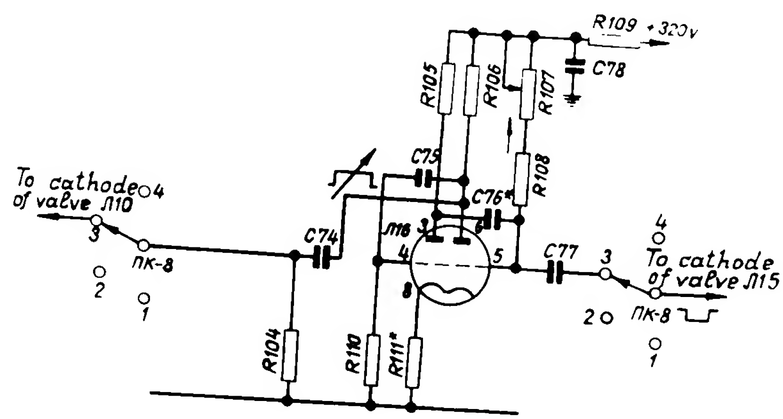



**Fig.17. Sweep delay.**

The physical processes which take place in the delay circuit boil down to the following: the positive potential applied to the right triode of the valve Л16, through the resistors R107 and R108, bias it to saturation current. The voltage drop across the resistor R111 creates a negative bias for the grid of the left triode of the Л16 valve, which is equal to the cut-off voltage. Thus the multivibrator is kept in a stable condition. A negative pulse from the potentiometer R100, in the third position of the ПК-8 switch, is applied to the grid of the right triode of the Л16 valve and nullifies the positive potential on this grid, causing the plate current of the right triode to decrease, as a result of which the voltage drop across the resistor R106 decreases, and the voltage on the plate of this triode increases.

This positive build-up of voltage is impressed through the condenser C75 upon the grid of the left triode of the valve Л16, opening it up and increasing the plate current of the left triode, as a result of which the voltage across the resistor R105 increas-

es, and, consequently, the voltage on the plate decreases. This negative voltage surge is impressed through the coupling condenser C76 upon the grid of the right triode, speeding up the operation process of the multivibrator until the plate current of the left triode reaches saturation, and the right triode is cut-off. After this condition has been reached, the positive voltage build-up on the plate of the right triode is discontinued, bringing the circuit to the initial condition. The time required for the completion of a full cycle is determined by the time constant of R107, R108 and the condenser C76. With a change in the value of the resistor R107, the time constant changes, and, consequently, the duration of the positive pulse on the plate of the right triode changes.

A positive pulse, of any duration, generated by the multivibrator, is fed to the differentiating circuit, which consists of the capacity C74 and the resistor R104.

The differentiated positive pulse is fed to the ПК-8 switch, which in its third position passes the pulse to the cathode of the right triode of the valve Л10, for starting the triggered sweep.

The positive short-duration peak formed on the front edge of the pulse generated by the multivibrator can not trigger the sweep, as the latter is triggered only by a negative pulse.

The negative peak formed on the back edge of the pulse, generated by the multivibrator, upon reaching the cathode of the right triode of the Л10 valve starts the triggered sweep.

The triggering of the triggered sweep will be delayed by a value, which is determined by the duration of the pulse generated by the multivibrator, since the sweep is triggered by the pulse formed (after differentiation) from the back edge of the pulse of the multivibrator, which is delayed with respect to the pulse starting the multivibrator, i.e. the pulse applied to the synchro-

plication input, by a time, determined by the duration of the pulse generated by the multivibrator.

C. Repetitive Sweep Oscillator

The repetitive sweep oscillator (valve J8) functions as an unbalanced multivibrator (Fig. 18).

The operation of the repetitive sweep multivibrator is similar to that of the sweep delay circuit, with the difference that it does not have a stable condition, but oscillates continuously.

The circuit functions in the following manner. If there is no plate voltage, both grids of the valve are at ground potential. As soon as the plate voltage is switched on, current flows through both halves of the valve, and a voltage drop appears across the resistor R59, limiting the plate current of the valve.

However, the circuit can not remain balanced. Let us suppose that as a result of shot effect or thermal fluctuations, the current of the left half of the valve increases. This current passing through the load resistor R60, lowers the voltage on the plate of the left half of the valve; as the voltage across the condenser C10--C13 can not change instantaneously, the drop in voltage on the plate of the left half of the valve is transmitted to the grid of the right half of the valve, decreasing the current of the right half of the valve.

This decrease in current lowers the voltage across the cathode resistor R59, consequently, the current through the left half of the valve increases. An increase of this current causes a further lowering of the voltage on the plate of the left half of the valve, and the current through the right half of the valve decreases still further. This process will continue until the current of the right half of the valve falls to zero, while the current of the left half of the valve reaches maximum.

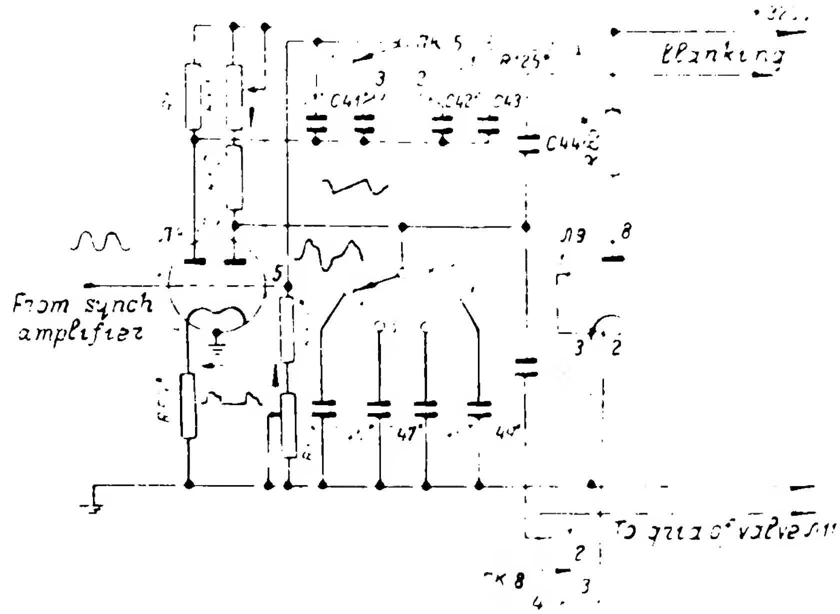


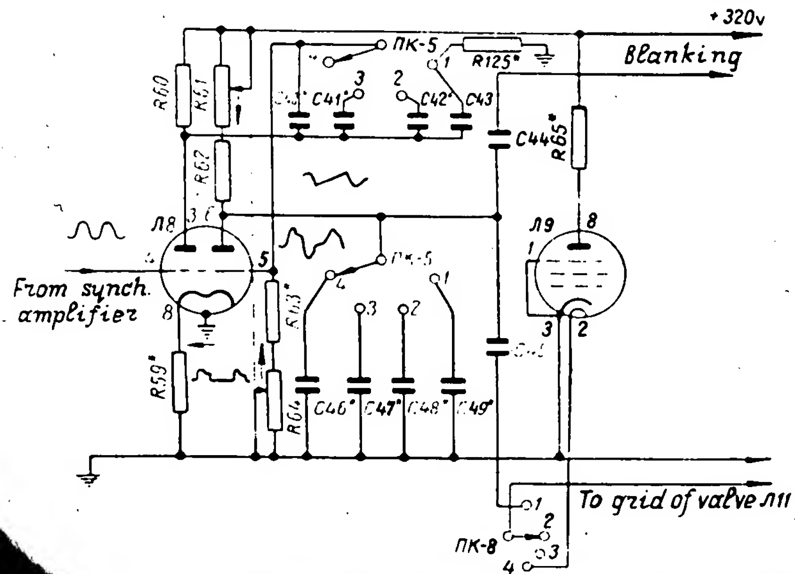

Fig. 16. Repetitive Sweep Oscillator.

In reality, the described process occurs almost instantaneously, as soon as the plate voltage is applied.

This condition of the circuit, when the right half of the valve is cut-off and the left half of the valve is open, lasts until the condenser C40-C48 discharges through the circuit R63, R64, R59 and the open left half of the valve.

The discharge current, passing through the resistors R63, R64 develops, on the grid of the right half of the valve, a voltage which is negative with respect to ground, and which falls off exponentially as the condenser discharges. After a while the negative voltage on the grid of the right half of the valve falls off to such a degree that this half of the valve begins to pass current.

The current of the right half of the valve will increase the voltage drop across the resistor R59. This increase of the voltage drop drives the grid of the left half of the valve negative, is-

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creasing the current passing through it.

As a result of the decrease in the current passing through the left half of the valve, the voltage on the plate of this valve will increase. As the voltage on the condenser C40--C43 cannot change instantaneously, the grid of the right half of the valve becomes positive, which increases still further the current flowing through the right half of the valve. In this case the current of the left half of the valve falls off to zero almost instantaneously, while the current flowing through the right half of the valve builds up to maximum.

This condition of the circuit, when the left half of the valve is cut off, and the right half of the valve is open, lasts until the condenser C40--C43 charges through R60, the open right half of the valve, or the resistors R63, R64, when the grid current of the right half of the valve stops flowing.

As the condenser charges, the bias on the grid of the right half of the valve decreases. This causes the current of this valve to decrease, and, consequently, the voltage on the cathode resistor R59 decreases.

When this voltage falls to the cut-off voltage, the left half of the valve opens and quickly cuts-off the right half of the valve, by feeding, through the condenser C40--C43, a voltage which is changing towards the negative.

Thus, the right half of the valve is cut off during the discharging of the condenser C40-C43, and begins passing current again when the charge on the condenser C40--C43 increases.

The charging and discharging times of the condenser are different. The discharging time is much greater than the charging time, as during discharging the right half of the valve is cut off, and the discharging proceeds through the large resistance of R63, R64.

The saw-tooth voltage required for sweeping is taken from the plate of the right half of the valve.

When the right half of the valve is cut off, the condenser C46-C49 charges through the resistors R61, R62 to the maximum value.

When the right half of the valve is open, the condenser C46-C49 discharges rapidly through the valve. However, the condenser C46-C49 does not have time to discharge fully, as in each position of the switch, the capacity of the condensers C46--C49 is about 10 times greater than the capacity of the condensers C40--C43.

As a result, the voltage taken from the condenser C46 --C49 changes within relatively narrow limits, at the same time the most linear section of the exponential charge curve of the condenser C46--C49 is used.

The frequency of the saw-tooth cycle can be controlled. The frequency of the saw-tooth voltage can be changed roughly by means of switching the condensers C40--C43 with the switch ПК-5, and smoothly by means of the ganged variable resistors R61-R64.

Thus with the aid of the rough and the fine controls, the time constants of the sweep condenser circuit and the frequency control circuit are changed proportionally.

The frequency of the saw-tooth oscillations depends to a great extent on the frequency of those oscillations that are fed to the grid of the left half of the valve from the synchronization amplifier.

If the frequency of the saw-tooth oscillations proper is equal to or a multiple of the frequency of the synchronizing voltage, then the multivibrator becomes "synchronized", and because of this the image on the screen of the tube becomes stationary.

While the condenser C46-C49 is charging, the beam travels across the screen from left to right (Forward time).

While the condenser C46-C49 is discharging, the beam returns to its initial position (return time).

The duration of the forward time is considerably greater than that of the return time, as a result, the return trace is poorly seen.

The sweep oscillator provides frequencies ranging from 10 to 100,000 c.p.s.

The switch ПК-5 has four positions. The first position of the switch corresponds to a frequency range of from 10 to 100 cycles, the second from 100 to 1000, the third from 1000 to 10,000, the fourth from 10,000 to 100,000 cycles.

The saw-tooth voltage taken from the condenser C46--C49 passes through the condenser C45 to the right half of the double triode valve Л11, which operates as a cathode repeater (see Fig. 18 and 20).

The potentiometer R78 serves as the cathode load, and from it the saw-tooth voltage is applied to the grid of the paraphase horizontal deflection amplifier.

Such a circuit allows the sweep voltage to be varied from zero to maximum without introducing any distortion into the sweep.

D. The Triggered Sweep Oscillator

The circuit diagram of the triggered sweep oscillator is shown in Fig.19. The triggered sweep oscillator can be triggered by a negative pulse from the plate of the Л15 valve of the synchronization amplifier or from the plate of the valve Л16 (if the triggered sweep is delayed).

In the first case, the sweep switch ПК-6 is set in the po-

sition "2", while in the second case it is set in the position "3".

The starting pulse is fed to the grid of the Л9 valve through a diode. The right half of the double triode valve Л10 serves as the diode.

The pulse from the synchronization amplifier or the sweep delay circuit passes through the switch ПК-8 and the condenser C60 to the cathode of the right half of the Л10 valve, then from its plate it is fed to the grid of the Л9 valve. For the negative pulses developed by the triggered sweep oscillator circuit, the diode presents a very large resistance. This ensures greater stability in the operation of the circuit, as after the completion of the starting pulse, the negatively charged condensers C51--C53 cannot discharge through the external circuits.

The triggered sweep oscillator is a multivibrator, operating two triodes.

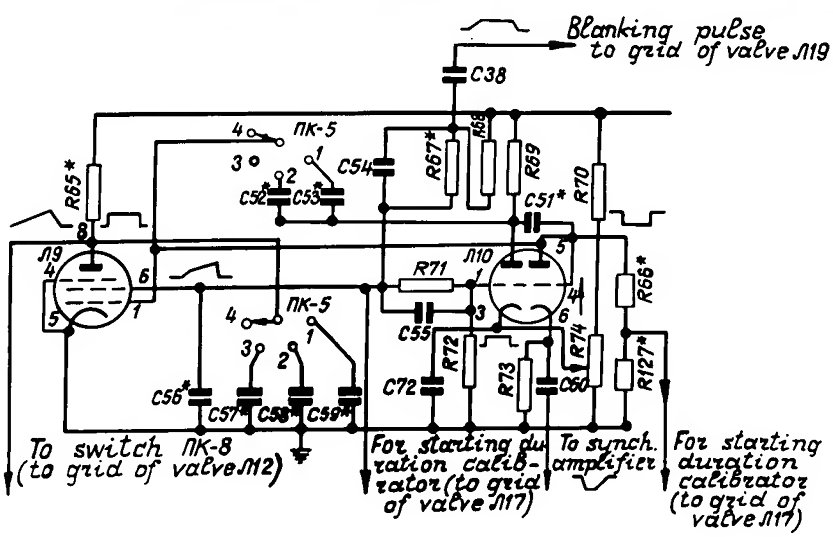



Fig.19. Triggered Sweep Oscillator.

The valve Л9, the screen grid of which functions as a plate, serves as one of the triodes. The left half of the valve Л10 serves as the other triode.

From the first, and until the beginning of operation (until the pulse arrives from the synchronization source) the triode part of the Л9 valve is fully conductive; the voltage on the grid is equal to the cathode potential, due to the presence of the resistor R66, while the plate potential (screen grid) is insignificant, due to the voltage drop across the resistors R67 and R68. The grid of the left triode of the valve Л10 has a considerable negative potential with respect to the cathode, as a result of which there is no current flowing through the left triode of the Л10 valve. The circuit remains in this condition until the arrival of a negative starting pulse. The pulse applied to the grid of the triode part of the valve Л9 cuts it off, causing the plate voltage (screen grid) to rise, as a result of the decrease in the voltage drop across the resistors R67 and R68. This increase in potential is applied to the grid of the left triode of the valve Л10 through the condenser C55.

Upon reaching the opening potential, current begins to flow through the left triode of the valve Л10, causing the negative pulse, passing through the condensers C51-C53 to the grid of the Л10 valve, to decrease, thus amplifying the external starting pulse. This process continues until the triode part of the Л9 valve is fully cut off, and the left triode of the Л10 valve fully open.

This condition is maintained until the condensers C51-C53, connected between the plate of the left triode of valve Л10 and the grid of the triode part of the valve Л9, are discharged through the resistor R66. During the discharging, the voltage

on the grid of the triode part of the valve Л9 increases exponentially with respect to the potential of the cathode. When the voltage passes the cut-off point in the positive direction, a transient process begins during which the triode part of the Л9 valve again becomes conductive, while the grid of the left triode of the Л10 valve does not receive a cut-off potential. Thus the circuit of the multivibrator is returned to the initial condition and "awaits" the next starting pulse, after which the whole cycle begins anew.

When the triode part of the Л9 valve becomes fully cut off, the potential on the plate of the Л9 valve rises sharply, due to which the condensers C56-C59 charge through the resistor R65. The voltage taken from these condensers is fed to the horizontal deflection amplifier, is amplified by it, and applied to the horizontal deflection plates of the cathode ray tube. This voltage is the sweep voltage.

The duration of the charging of condensers C56-C59 is so short that the total increase in voltage constitutes only a few per cent of the supply voltage, thus ensuring the linearity of the triggered sweep.

The duration of the process occurring in the triggered sweep oscillator does not depend on the shape or duration of the starting pulse, which makes the latter convenient for controlling the horizontal sweep of the beam of the cathode ray tube.

The time constants of the triggered sweep oscillator are selected so that the sweep speeds can be varied.

With the aid of the switch ПК-5, which switches the condensers C51-C53 and C56-C59 (the switches are ganged), it is possible to obtain four different sweep speeds. The position "1" of the ПК-5 switch corresponds to a speed of 250 microseconds. The position "2" corresponds to a speed of 50 microseconds. The position

"3" corresponds to a speed of 10 microseconds. And the position "4" corresponds to a speed of 2 microseconds.

With the aid of the voltage divider consisting of the resistors R67, R68, R71, R72, the increase in potential from the screen grid of the Л9 valve is fed through the coupling condenser C38 to the control grid of the cathode ray tube opening it. In addition, through the condensers C86 and C87, the positive pulse is fed to the grid of the negative-resistance oscillator valve Л17 (the duration calibrator) starting it.

The variable resistor R74 in the cathode lead of the Л10 valve is adjusted by means of a screw driver. In some cases, for example, after replacing the Л10 valve, the sensitivity and stability of the triggered sweep oscillator may be adjusted with the aid of the resistor R74.

## E. The Horizontal Deflection Amplifier

The circuit diagram of the horizontal deflection amplifier (valves Л12 and Л13) is shown in Fig.20. From the diagram it can be seen that the horizontal deflection amplifier functions as a paraphase amplifier.

The circuit of the horizontal deflection amplifier is similar to that of the vertical deflection output amplifier shown in Fig.14. There is only some difference in the values of the plate loads (resistors R80 and R84) and the correction inductances (coils L10 and L13) which are somewhat greater in the horizontal deflection amplifier than in the vertical deflection amplifier. This is due to the fact that greater gain is required from the horizontal deflection amplifier, and that its frequency response does not have to be as uniform as that of the vertical deflection amplifier. The beam is shifted horizontally with the

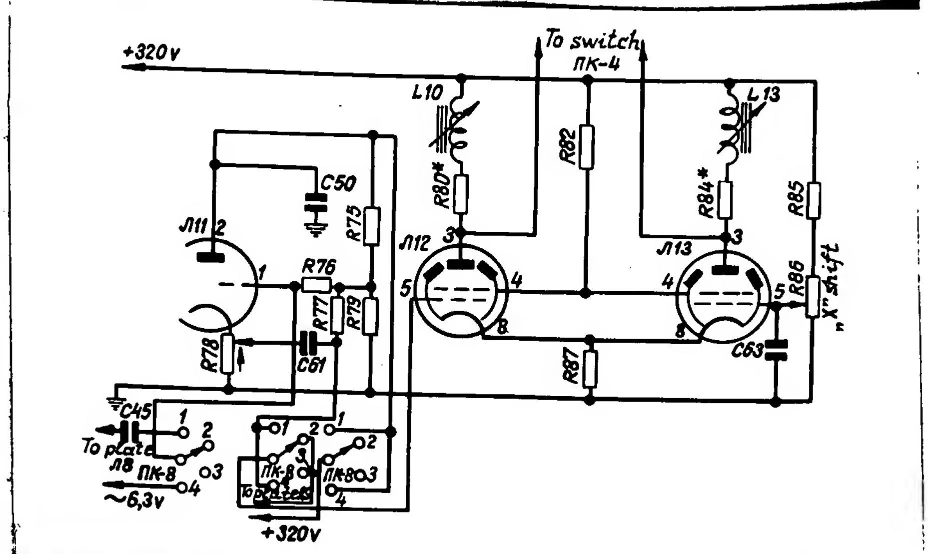



Fig.20. Horizontal Deflection Amplifier.

of the potentiometer R86, the knob of which is located on the front panel.

The voltage of the triggered sweep oscillator is fed directly from the plate of the Л9 valve to the grid of the Л12 valve. The voltage of the repetitive sweep or the main (for sweeping sinusoidal voltages) is first applied to the grid of the right half of the double triode Л11, which functions as a cathode repeater.

This makes it possible to regulate the horizontal gain from zero to maximum without loading the repetitive sweep oscillator. Sweep voltages are fed to the horizontal deflection amplifier in both cases via the sweep switch ПК-8.

3. The Pulse Duration Calibrator

The circuit diagram of the pulse duration calibrator is shown in Fig.21. The principal part of the circuit is the negative-resistance oscillator (valve Л17).

A negative-resistance oscillator is one with a falling-off

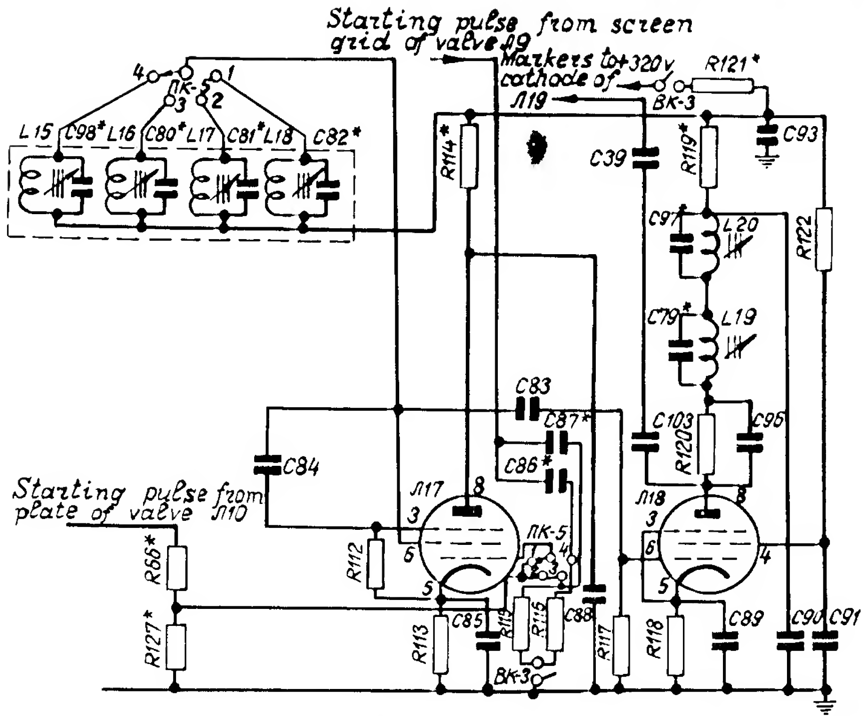



Fig.21. Pulse Duration Calibrator.

volt-ampere characteristic, due to which a tuned circuit connected to the screen-grid circuit causes oscillations to occur in the latter, at a frequency very close to the fundamental frequency of the tuned circuit, if the total impedance of the tuned circuit at resonance is greater than the absolute value of the negative resistance at the working point of the characteristic.

One of the advantages of the negative-resistance oscillator is the ease with which it can be synchronized with an external pulse. The parameters of the circuit are selected so that during absence of the pulse on the grid of the Л17 valve, the oscillator either does not oscillate or oscillates very weakly.

When a starting pulse is fed from the triggered sweep oscillator circuit to the grid of the Л17 valve, sinusoidal high-frequency oscillations arise in the negative-resistance oscillator circuit, which are used as calibration markers. The frequency of the calibration markers depends upon which of the tuned circuits

is switched into the screen-grid circuit of the valve.

The tuned circuits are switched with the aid of the ПК-5 switch which is ganged with the triggered sweep speed switch.

When the ПК-5 switch is in position "1", the frequency of the oscillations generated by the oscillator is equal to 0.1 mc.

In this case the sweep speed is equal to 250 microseconds, consequently, 25 calibration markers, spaced 10 microseconds apart, will lie on the sweep line. When the ПК-5 switch is in position "2", the frequency of the oscillator is equal to 0.5 megocycles. In this case the sweep speed will be equal to 50 microseconds, and consequently, 25 calibration markers, spaced 2 microseconds apart, will lie on the sweep line. When the ПК-5 switch is in position "3", the frequency of the oscillator is equal to 2 mc. In this case the sweep speed is equal to 10 microseconds, and consequently 20 calibration markers, spaced 0.5 microseconds apart, will lie on the sweep line.

When the ПК-5 switch is in the position "4", the frequency of the oscillator is equal to 10 mc. In this case the sweep speed is equal to 2 microseconds, and consequently, 20 calibration markers, spaced 0.1 microseconds apart, will lie on the sweep line.

The wide range of frequencies generated by the negative resistance oscillator (from 0.1 to 10 mc.) does not make it possible to obtain calibration markers of the same magnitude and to apply them directly to the cathode of the cathode ray tube, in order to modulate the brightness of the beam.

The amplitude of the high-frequency oscillations is considerably smaller than the amplitude of the low-frequency oscillations, and is not large enough to modulate the brightness of the beam. Because of this the oscillations from the tuned circuits of the negative resistance oscillator are fed through the coupling condenser C38 to the grid of the amplifying stage (valve Л16), and

after amplification are taken from the plate load R120 and through the condensers C103 and C59 impressed on the cathode of the tube.

The parameters of the amplifier are selected so that the frequency response from 0.1 to 10 mc is sufficiently uniform.

In order to boost the gain at very high frequencies, the resonant circuits L19, C79 and L20, C97 are inserted in the plate circuits of the valve.

The amplifier not only amplifies the high-frequency oscillations from the negative-resistance oscillator, but to a certain degree evens out the amplitude of the calibration markers applied to the cathode of the tube. At low frequencies (0.1 mc.), the amplitude of the oscillations fed by the oscillator is great. These oscillations on being applied to the grid of the J18 valve are somewhat reduced (positive half wave) due to grid currents of the J18 valve.

Thus the amplitude of the calibration markers applied to the cathode of the cathode ray tube is nearly equal for all calibration frequencies.

From the above, it can be gathered that the calibration oscillations have a nearly sinusoidal shape, as a result of which, the positive half waves fed to the cathode of the tube decrease somewhat the brightness of the beam, while the negative half waves fed to the cathode increase the brightness of the beam. As a result the sweep line appears as a series of dark patches and light spots. Knowing the spacing of the spots (in microseconds), it is easy to determine the duration of the pulse under test.

4. Pulse Amplitude Calibrator

The a-c calibration voltage (at mains frequency) is taken from part of the secondary winding of the power transformer and fed to a voltage divider consisting of the resistor R9 and the

potentiometer R47 (see Fig.22) from where it is fed to the input attenuator, and attenuated by it at a factor of 1:100. The voltage taken from the potentiometer R47 and fed to the input attenuator is measured with the aid of a diode vacuum valve voltmeter, using the left half of the double triode Л11.

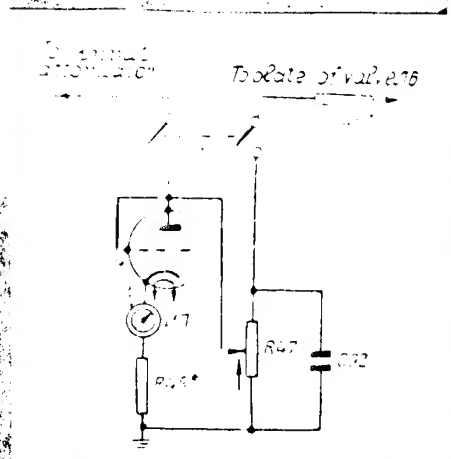



Fig.22. Amplitude calibrator.

The instrument used by the vacuum valve voltmeter is a 100-ma microammeter, type ЛМС-100. The scale of the milliammeter is calibrated in amplitude values.

The procedure of measuring the amplitude of the pulse under test is described in part II.

5. Power Unit and the Cathode Ray Tube Supply Circuit

The circuit diagram of the power unit and the cathode ray tube supply circuit is shown in Fig.23. The power unit consists of the power transformer T1 and two kenotron rectifiers. The high-voltage rectifier, which supplies the cathode ray tube (valve 7), functions as a half-wave rectifier and has a single-section filter consisting of the resistor R48 and the high-voltage condensers C35 and C36. The rectified voltage delivered by the rectifier is approximately 2000 volts before the filter.

The low-voltage rectifier which supplies all the plate circuits and screen-grid circuits (valve Л6) functions as a full-wave rectifier and has a two-stage filter consisting of the chokes L8, L9 (3.5 Henry each) and three groups of electrolytic condensers C27, C28--C29, and C30, C32. The rectifier delivers 350 volts before the filter and 320 volts after the filter.

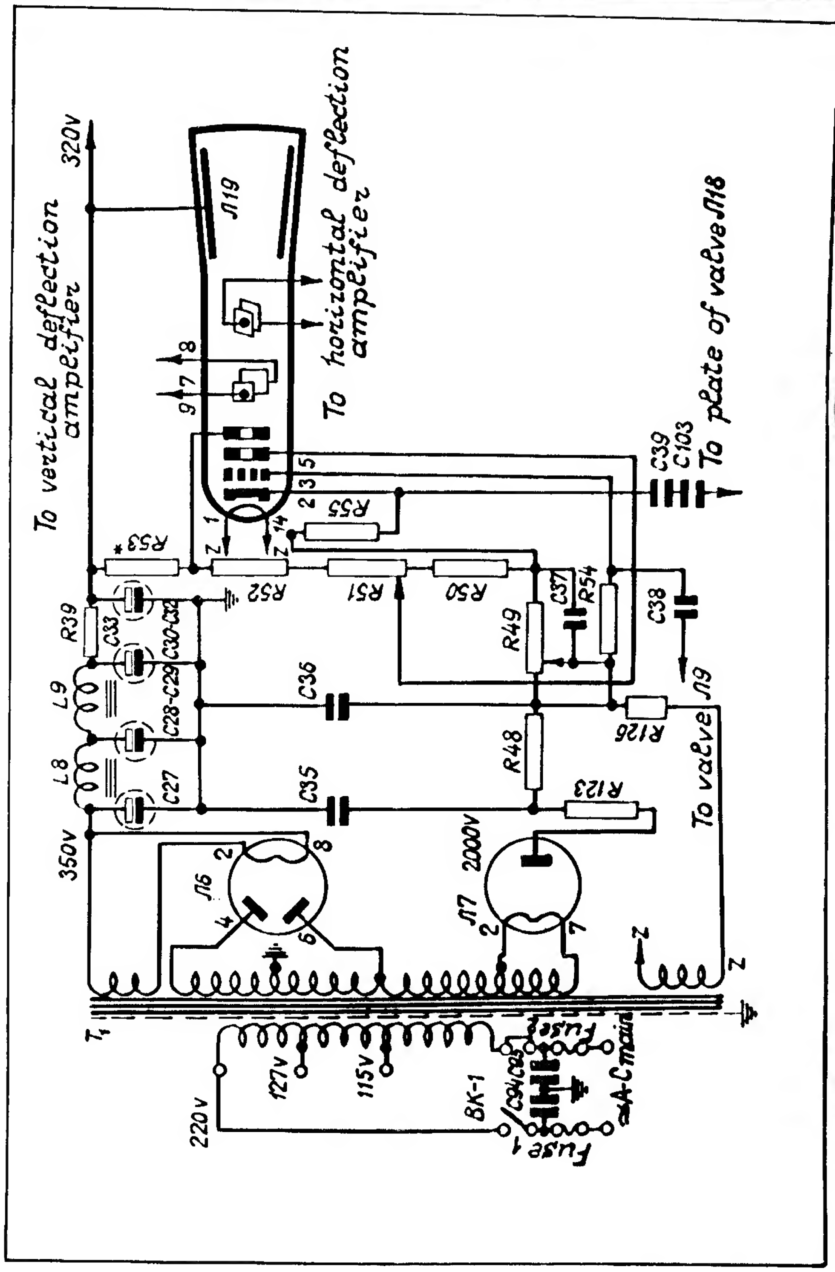



Fig.23. Power Unit and Cathode Ray Tube Supply Circuit.

The power transformer is designed for operation from a-c mains of 115, 127, and 220 volts, for which its primary winding is sectionalized. In the primary winding circuit of the power transformer are inserted the power switch BK-1 and the inter-lock button BK-2 for switching off the Synchroscope when it is removed from the case.

In addition, the fuse ΠP, rated at 2 amps, is inserted in one of the leads of the power transformer. In addition to the primary winding, the power transformer has two step-up windings and five step-down windings, of which two serve for supplying the rectifier heaters (5 volt and 2.5 volt), one supplies the heater of the cathode ray tube (6.3 volt) and two supply all the valve heaters which are divided into two groups (6.3 volt).

The cathode ray tube, as has been stated above, is supplied by a special high-voltage rectifier.

If the potential on the cathode of the tube is taken for zero, the rest of the electrodes of the cathode ray tube will have the following potentials.

The third anode will have 1650 volts. This voltage is taken from the whole of the potentiometer R50, R51, and R52. The voltage on the first anode can change from 400 to 700 volts. This voltage is taken from the potentiometer R51. The adjustment of this voltage focusses the beam. The negative voltage on the control electrode of the tube is taken from the potentiometer R49. This voltage can reach 50 volts. The adjustment of this voltage controls the brightness of the image on the screen of the tube.

The deflection plates of the tube are constantly at a positive potential equal to that of the third anode.

The voltage of the signal under test is applied to the vertical deflection plates through the switch ΠK-3. In one position of the ΠK-3 switch, the deflecting voltage is fed directly from

the output of the vertical-deflection amplifier. In the other position of the ПК-3 switch, the deflecting voltage is fed from the jack Г3 through the de-coupling condensers C22 and C23. In order that in this position of the switch (when external voltage is fed to the plates), the plates would remain at the constant potential of the third anode, the ПК-3 switch is shunted by the resistors R43 and R44.

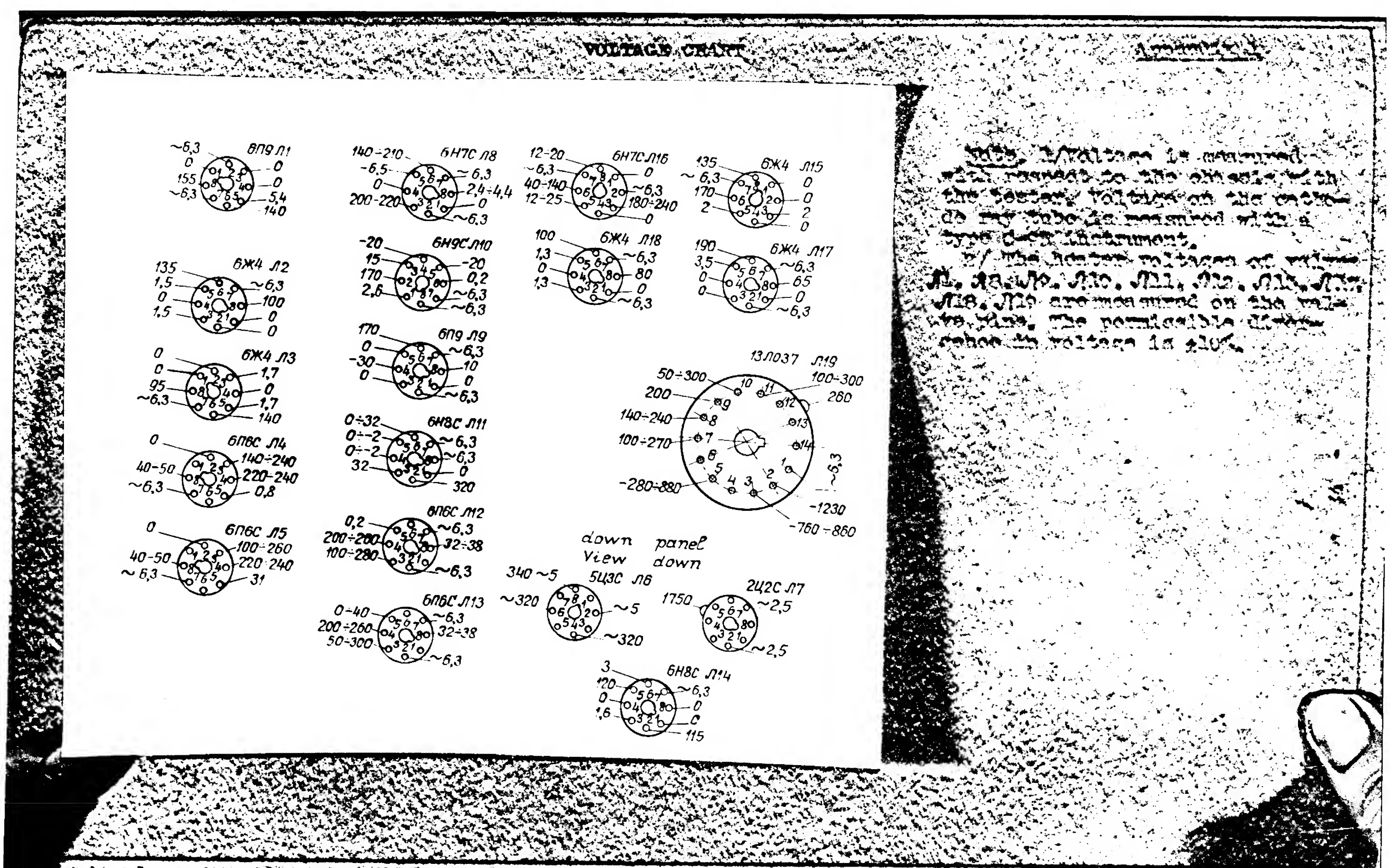
The voltage of the sweep signal is applied to the horizontal deflection plates through the switch ПК-4. Voltage to the horizontal deflection plates is fed from the output of the horizontal deflection amplifier or from the external jacks Г4 through the de-coupling condensers C24 and C25. The ПК-4 switch is shunted by the resistors R56 and R57.

The blanking pulse is applied to the grid of the tube through the de-coupling condenser C38.

The voltage of the calibration markers is applied to the cathode of the tube through the de-coupling condensers C105 and C39 from the duration calibrator.

ATTENTION! In the spare-valve box there are valves, specially selected according to paragraph 3 of the log, intended only for replacing the corresponding valves of the synchroscope, in case the latter should become bad.

The use of these valves for other purposes is NOT ALLOWED.


VOLTAGE CHART
6П9 Л1
6Ж4 Л2
6Ж4 Л3
6П6С Л4
6П6С Л5
6Н7С Л8
6Н9С Л10
6П9 Л9
6Н8С Л11
6П6С Л12
6П6С Л13
6Н7С Л16
6Ж4 Л18
6Ж4 Л15
6Ж4 Л17
13ЛО37 Л19
down view
panel down
5Ц3С Л6
2Ц2С Л7
6Н8С Л14

Appendix 2.

POSSIBLE FAULTS

| No. | Fault | Cause | Remedy |
|---|---|---|---|
| 1 | The pilot lamp does not burn | a) lamp has burned out | Replace |
| | | b) the fuse has burned out | " |
| | | c) the power switch is out of order | " |
| | | d) open circuit in the supply cord | Repair |
| | | e) interlock button out of order | " |
| 2 | No beam | a) valve Л 7 is inoperative | Replace |
| | | b) valve Л 6 is inoperative | " |
| | | c) divider R48 and R53 is out of order | Check |
| | | d) bad contact in socket of cathode ray tube | Repair |
| | | e) cap has fallen off of anode III | Put back |
| 3 | Fuse keeps burning out | Short circuit to ground | Remove all valves including rectifiers. Burning out of the fuse, with rectifier valve removed indicates a fault in the power transformer or a short in the heater circuits. Burning out of the fuse with rectifier in place indicates short to ground in plate circuits. In this case, check rectifiers, electrolytic condensers C27--C28--C29--C30--C32--C33--C28--and plate cicuits of all valves. |

| No. | Fault | Cause | Remedy |
|---|---|---|---|
| 4 | Beam does not shift verti- cally | a) Faulty valves Л4--Л5 | Replace |
| | | b) Faulty divider R29--R30 | Check |
| | | c) Faulty divider R37--R38 | Check |
| | | d) Open circuit in coils L4--L5 | Check |
| | | e) Burnt out resis- tor R41 | Check and replace |
| 5 | Beam does not shift in repe- titive sweep position | a) Faulty valves Л12--Л13 | Replace |
| | | b) Faulty divider R75--R74 | Check |
| | | c) Faulty divider [illegible]--R86 | " |
| | | d) Open circuit in coils L10-L13 | " |
| | | e) Burnt out resis- tor [illegible] | Check and replace |
| 6 | No vertical gain | a) Open circuit in cable | Repair |
| | | b) Faulty valves Л1--Л2--Л3 | Replace |
| | | c) Faulty switches ПК-1 and ПК-2 | Check and repair |
| | | d) Punctured decoupl- ing electrolytic con- densers C15--C20--C39 | Check and replace |
| | | e) Faulty potentio- meter R12 | Check and replace |
| 7 | No repetitive sweep | a) Faulty valves Л8 or Л11 | Replace |
| | | b) Faulty switches ПК-5 or ПК-6 | Check and repair |

| No. | Fault | Cause | Remedy |
|---|---|---|---|
| 8 | No triggered sweep | a) Faulty valves Л9 or Л10 | Replace |
| | | b) Faulty switches ПК-5 or ПК-8 | Check and repair |
| 9 | Self-starting of triggered sweep | Disalignment | Set switch ПК-6 in position "intern."; ПК-7 in position "-". Adjust potentiometer R74 at self-starting threshold. |
| 10 | Synchronization does not function: I. In position "intern." with vertical gain | a) Faulty switches ПК-6, ПК-7 | Check, replace |
| | | b) Faulty valves Л14, Л15 | Replace |
| | | c) Faulty switch ПК-8 | Check, replace |
| | II. In position "extern." | a) Bad contact in "External synch." jack | Repair |
| | | b) Faulty switch ПК-6 | Check, replace |
| 11 | No delayed triggered sweep | a) Faulty valve Л16 | Replace |
| | | b) Faulty switch ПК-8 | Check and replace |
| | | c) Faulty variable resistor R107 | Replace |
| 12 | Duration calibrator does not function | a) Faulty valves Л17, Л18 | Replace |
| | | b) Faulty switch ПК-5 | Check and repair |
| | | c) Faulty switch ВК-[illegible] | Check and repair |
| | | d) Cores disaligned | Align |
| 13 | Amplitude calibrator does not function | a) Faulty valve Л11 | Replace |
| | | b) Faulty switch ПК-10 | Check and replace |
| | | c) Faulty switch ПК-1 | Check and replace |
| | | d) Check motor | Repair |

NOTE. Before using the Synchroscope check that the horizontal and vertical amplifiers are switched on.

Appendix [illegible]

## SPECIFICATIONS TO CIRCUIT DIAGRAM
## OF THE 25И SYNCHROSCOPE

| Circuit designation | Description | Type | Data | Cipher | Note |
|---|---|---|---|---|---|
| Л1 | Vacuum valve | 6П9 | | | |
| Л2 | Ditto | 6Ж4 | | | |
| Л3 | " | 6Ж4 | | | |
| Л4 | " | 6П3С | | | |
| Л5 | " | 6П3С | | | |
| Л6 | " | 5Ц3С | | | |
| Л7 | " | 2Ц2С | | | |
| Л8 | " | 6Н7С | | | |
| Л9 | " | 6П9 | | | |
| Л10 | " | 6Н9С | | | |
| Л11 | " | 6Н8С | | | |
| Л12 | " | 6П6С | | | |
| Л13 | " | 6П6С | | | |
| Л14 | " | 6Х6С | | | |
| Л15 | " | 6Ж4 | | | |
| Л16 | " | 6Н7С | | | |
| Л17 | " | 6Ж4 | | | |
| Л18 | " | 6Ж4 | | | |
| 19 | Cathode ray tube | 13ЛО37 | | | |
| 20 | Pilot lamp | | 13.5 v.<br>0.18 amp. | | |
| C1 | Ceramic condenser | КТК-1-[illegible] | 10 mmf ±2%;<br>500 v. | | Selected from КТК-[illegible]<br>10 mmf [illegible] |
| C2 | Trimmer | КПК-1 | 2 ÷ 7 mmf | | |
| C3 | Trimmer | КПК-1 | 6 ÷ 25 mmf ТУ 108-49 | | |
| C4 | Trimmer | КПК-[illegible] | 6 ÷ 25 mmf ТУ 108-49 | | |

| Circuit designation | Description | Type | Data | Cipher | Note |
|---|---|---|---|---|---|
| C5 | Trimmer | КПК-1 | 6÷25 mmf | ГУ108-49 | |
| C6 | Mica condenser | КСО-2 | 100 mmf±5%; 500 v. | | |
| C7 | Trimmer | КПК-1 | 6÷25 mmf | ГУ108-49 | |
| C8 | Mica condenser | КСО-2 | 1000 mmf±5%; 500 v. | | |
| C9 | Paper hermetical condenser | КБГ-И | 0.05 mfd±10%; 200 v. | | |
| C10 | Paper hermetical condenser | КБГ-МП (2a)И | 0.5 mfd±10%; 600 v. | | |
| C11 | Mica condenser | КСО-1 | 150 mmf±10%; 250 v. | | Selected during alignment |
| C12 | Paper hermetical condenser | КБГ-М2 | 0.25 mfd±10%; 200 v. | | |
| C13 | Mica condenser | КСО-2 | 1000 mmf ±10%; 500 v. | | Selected during alignment |
| C15 | Electrolytic condenser | КЭ-2-М | 20 mfd; 450 v. | | |
| C16 | Paper hermetical condenser | КБГ-И | 0.05 mfd ±10%; 400 v. | | |
| C17 | Mica condenser | КСО-2 | 560 mmf ±10%; 500 v. | | Selected during alignment |
| C19 | Paper hermetical condenser | КБГ-И | 0.05 mfd ±10% 400 v. | | |
| C20 | Electrolytic condenser | КЭ-2-М | 20 mfd; 450 v. | | |
| C21 | Paper hermetical | КБГ-И | 0.05 mfd±10%; 200 v. | | |
| C22 | Ditto | КБГ-И | 0.05 mfd±10%; 400 v. | | |
| C23 | " | КБГ-И | 0.05 mfd ±10%; 400 v. | | |
| C24 | " | КБГ-И | 0.05 mfd ±10%; 400 v. | | |

| Circuit designation | Description | Type | Data | Cipher | Note |
|---|---|---|---|---|---|
| C25 | Paper hermetical condenser | КБГ-Н | 0.05 mfd ±10%; 400 v. | | |
| C26 | Electrolytic condenser | КЭ-2-М | 20 mfd; 450 v. | | |
| C27 | Ditto | КЭ-2-М | 20 mfd; 450 v. | | |
| C28 | " | КЭ-2-М | 20 mfd; 450 v. | | |
| C29 | " | КЭ-2-М | 20 mfd; 450 v. | | |
| C30 | " | КЭ-2-М | 20 mfd; 450 v. | | |
| C32 | " | КЭ-2-М | 20 mfd; 450 v. | | |
| C33 | " | КЭ-2-М | 20 mfd; 450 v. | | |
| C34 | " | КЭ-2-М | 20 mfd; 450 v. | | |
| C35 | Paper-oil condenser | БМ-01 | 0.4 mfd ±10%; 2000 v. | | |
| C36 | Ditto | БМ-01 | 0.4 mfd ±10%; 2000 v. | | |
| C37 | Paper hermetical condenser | КБГ-Н | 0.5 mfd ±10%; 400 v. | | |
| C38 | Mica condenser | КСО-6 | 1000 mmf ±10%; 1000 v. | | |
| C39 | Mica condenser | КСО-6 | 120 mmf; 1000 v. | | |
| C40 | Ceramic condenser | ККК-1-М | 33 mmf ±10%; 500 v. | | Selected during alignment |
| C41 | Mica condenser | КСО-2 | 470 mmf ±10%; 500 v. | | Ditto |
| C42 | Mica condenser | КСО-6 | 4700 mmf ±10%; 500 v. | | " |
| C43 | Paper hermetical condenser | КБГ-Н | 0.05 mfd ±10%; 400 v. | | |
| C44 | Ceramic condenser | ККК-1-М | 22 mmf ±10%; 500 v. | | |
| C45 | Paper hermetic- | КБГ-МП (2 x 1 M) | 0.25 mfd ±10%; 600 v. | | |

| Circuit designation | Description | Type | Data | Other | Note |
|---|---|---|---|---|---|
| C46 | Mica condenser | KCO-2 | 220 mmf ±10%; 500 v. | | Selected during alignment |
| C47 | Mica condenser | KCO-5 | 6800 mmf ±10%; 500 v. | | Ditto |
| C48 | Paper hermetical condenser | КБГ-И | 0.05 mfd ±10%; 400 v. | | " |
| C49 | Paper hermetical condenser | КБГ-МП (2а)И | 0.5 mfd ±10%; 600 v. | | |
| C50 | Mica condenser | KCO-2 | 1000 mmf ±10%; 500 v. | | |
| C51 | Ceramic condenser | КТК-1-М | 10 mmf ±10%; 500 v. | | Selected during alignment |
| C52 | Mica condenser | KCO-2 | 150 mmf ±10%; 500 v. | | Ditto |
| C53 | " " | KCO-2 | 1000 mmf ±10%; 500 v. | | |
| C54 | " " | KCO-2 | 1000 mmf ±10%; 500 v. | | |
| C55 | " " | KCO-2 | 180 mmf ±10%; 500 v. | | |
| C56 | Ceramic condenser | КТК-1-М | 10 mmf ±10%; 500 v. | | Selected during alignment |
| C57 | Mica condenser | KCO-2 | 330 mmf ±10%; 500 v. | | Ditto |
| C58 | Mica condenser | KCO-5 | 1800 mmf ±10%; 500 v. | | " |
| C59 | Paper hermetical condenser | КБГ-И | 0.01 mfd ±10%; 600 v. | | |
| C60 | Mica condenser | KCO-2 | 470 mmf ±10%; 500 v. | | |
| C61 | Paper hermetical condenser | КБГ-МП (2а)И | 0.25 mfd ±10%; 600 v. | | |
| C63 | Paper hermetical condenser | КБГ-И | 0.05 mfd ±10%; 200 v. | | |

| Circuit designation | Description | Type | Data | Cipher | Note |
|---|---|---|---|---|---|
| C64 | Paper hermetical condenser | КБГ-И | 0,05 mfd ±10%; 400 v. | | |
| C65 | Paper hermetical condenser | КБГ-И | 0,05 mfd ±10%; 400 v. | | |
| C66 | Ceramic condenser | КТК-1 | 16 mmf ±10%; 500 v. | | |
| C67 | Electrolytic condenser | КЭ-2 | 20 mfd; 450 v. | | |
| C68 | Paper hermetical condenser | КБГ-МП (2x) | 0,25 mfd ±10%; 400 v. | | |
| C69 | Paper hermetical condenser | КБГ-И | 0,05 mfd ±10%; 200 v. | | |
| C70 | Paper hermetical condenser | КБГ-И | 0,05 mfd ±10%; 400 v. | | |
| C71 | Electrolytic condenser | КЭ-2 | 20 mfd; 150 v. | | |
| C72 | Mica condenser | КСО-2 | 470 mmf ±10%; 500 v. | | |
| C73 | Paper hermetical condenser | КБГ-И | 0,05 mfd ±10%; 400 v. | | |
| C74 | Ceramic condenser | КТК-1 | 22 mmf ±10%; 500 v. | | |
| C75 | Paper hermetical condenser | КБГ-И | 0,025 mfd ±10%; 300 v. | | |
| C76 | Mica condenser | КСО-2 | 150 mmf ±10%; 500 v. | | Selected during alignment |
| C77 | Mica condenser | КСО-2 | 470 mmf ±10%; 500 v. | | |
| C78 | Paper hermetical condenser | КБГ-2 | 0,25 mfd ±10%; 100 v. | | |
| C79 | Ceramic condenser | КТК-1 | 10 mmf ±10%; 500 v. | | Selected during alignment |
| C80 | Mica condenser | КСО-2 | 100 mmf ±10%; 500 v. | | Ditto |
| C81 | Mica condenser | КСО-2 | 330 mmf ±10%; 500 v. | | |

| Circuit designation | Description | Type | Data | Cipher | Note |
|---|---|---|---|---|---|
| C82 | Mica condenser | KCO-5 | 1200 mmf ±10%; 500 v. | | |
| C83 | Mica condenser | KCO-2 | 300 mmf ±10%; 500 v. | | Selected during alignment |
| C84 | Mica condenser | KCO-2 | 470 mmf ±10%; 500 v. | | |
| C85 | Paper hermetical condenser | KБГ-И | 0.05 mfd ±10%; 200 v. | | Selected during alignment |
| C86 | Mica condenser | KCO-2 | 820 mmf ±10%; 500 v. | | Ditto |
| C87 | Mica condenser | KCO-2 | 100 mmf ±10%; 500 v. | | |
| C88 | Paper hermetical condenser | KБГ-И | 0.05 mfd ±10%; 400 v. | | |
| C89 | Ditto | KБГ-И | 0.05 mfd ±10%; 200 v. | | |
| C90 | " | KБГ-И | 0.05 mfd ±10%; 400 v. | | |
| C91 | " | KБГ-И | 0.05 mfd ±10%; 400 v. | | |
| C92 | Mica condenser | KCO | 9200 mmf ±20%; 500 v. | | |
| C93 | Paper hermetical condenser | KБГ-МП (2ф)И | 0.25 mfd ±10%; 400 v. | | |
| C94 | Mica condenser | KCO-5 | 4700 mmf ±10%; 500 v. | | |
| C95 | Ditto | KCO-5 | 4700 mmf ±10%; 500 v. | | |
| C96 | Ceramic condenser | KTK-2-M | 47 mmf ±10%; 500 v. | | |
| C97 | Ditto | KTK-2-M | 47 mmf ±10%; 500 v. | | |
| C98 | " | KTK-1-M | 10 mmf ±10%; 500 v. | | Selected during alignment |
| C99 | " | KTK-1-M | 27 mmf ±10%; 500 v. | | |

| Circuit designation | Description | Type | Data | Cipher | Note |
|---|---|---|---|---|---|
| C100 | Ceramic condenser | KTK-1-M | 10 mmf ±10%; 500 v. | | |
| C101 | Ditto | KTK-1-M | 10 mmf ±10%; 500 v. | | |
| C102 | Paper hermetical condenser | КБГ-М | 0.02 mfd ±10%; 200 v. | | |
| R1 | Fixed carbon resistor | BC-0.25 | 4.6 megohm ±1% | | Selected from 4.7-megohm ±10% during alignment |
| R2 | Ditto | BC-0.25 | 75 ohm ±1% | | from 150-ohm ±5% two in parallel |
| R3 | " | BC-0.25 | 629 kiloohm ±1% | | from 620-kilo-ohm±5% or 1.2-megohm±5% and 1.3-megohm±10% in parallel |
| R4 | " | BC-0.25 | 459 kiloohm ±1% | | from 470-kilo-ohm ±5% or 820-kiloohm ±10% and 1.1-megohm ±10% in parallel |
| R5 | Fixed carbon resistor | BC-0.25 | 505 kiloohm ±1% | | from 510-kilo-ohm ±5% |
| R6 | Ditto | BC-0.25 | 51 kiloohm ±1% | | from 51-kilo-ohm ±5% |
| R7 | " | BC-0.25 | 5.1 kiloohm±1% | | Selected from 5.1-kiloohm ±5% with mutual tolerance ±1% |
| R8 | Fixed carbon resistor | BC-0.25 | 2.7 megohm ±10% | | |
| R9 | Ditto | BC | 19.5 kiloohm±10% | | BC-1 39 kilo-ohm±10%; two in parallel |
| R10 | " | BC | 19.5 kiloohm±10% | | BC-1 39-kilo-ohm±10%; two in parallel |
| R11 | " | BC-1 | 27.1 kiloohm ±10% | | |

| Circuit designation | Description | Type | Data | Cipher | Note |
|---|---|---|---|---|---|
| R12 | Variable resistor | СП-1-2а | 1 kiloohm-A | | Selected from BC-0.25 resistors connected in parallel; 680-ohm±10% and BC-0.25 |
| R13 | Fixed carbon resistor | BC-0.25 | 390 ohm ±10% | | 560-ohm±10% or 300-ohm ±10% |
| R14 | Ditto | BC-0.25 | 300 ohm ±1% | | Selected from mutual tolerance of ±1% with R40 |
| R15 | Fixed carbon resistor | BC-0.25 | 480 ohm ±1% | | Selected from 470-ohm±10% or 300-ohm±10% and 180-ohm±10% in series |
| R16 | Fixed carbon resistor | BC-0.25 | 540 ohm ±1% | | Selected from 560-ohm±10% or 300-ohm±10% and 240-ohm ±10% |
| R17 | Ditto | BC-0.25 | 1.5-kiloohm ±10% | | Selected during alignment of R12 to 600 ohm |
| R18 | Fixed carbon resistor | BC-0.25 | 2.7 megohm ±10% | | |
| R19 | Fixed carbon resistor | BC-0.5 | 100 ohm ±10% | | |
| R20 | Ditto | BC | 7.2 kiloohm±5% | | Selected from BC-1 resist. connected in parallel: three 47-kiloohm±10%, three 39-kiloohm ±10% |
| R21 | " | BC-0.25 | 330 ohm ±10% | | Selected during alignment |
| R22 | " | BC-1 | 2.4 kiloohm±5% | | |
| R23 | " | BC-1 | 1.2 kiloohm±10% | | |
| R24 | " | BC-0.25 | 1 kiloohm±10% | | |
| R25 | " | BC-1 | 2.4 kiloohm±5% | | Selected during alignment |

| Circuit designation | Description | Type | Data | Cipher | Note |
|---|---|---|---|---|---|
| R26 | Fixed carbon resistor | BC-0.25 | 56 ohm±10% | | |
| R27 | Ditto | BC-0.5 | 240 kiloohm±10% | | |
| R28 | " | BC-0.5 | 150 ohm ±10% | | |
| R29 | " | BC-0.5 | 1 megohm±10% | | |
| R30 | " | BC-0.25 | 150 kiloohm ±1% | | |
| R31 | Fixed carbon resistor | BC-0.25 | 1 megohm ±10% | | |
| R32 | Ditto | BC-0.25 | 66.6 ohm ±1% | | Selected from 68-ohm ±10% or two 130-ohm ±10% in parallel |
| R33 | Fixed carbon resistor | BC | 2.4 kiloohm ±5% | | Selected from five BC-2 resistors in parallel 12-kiloohm ±10% |
| R34 | Ditto | BC-1 | 2.7 kiloohm±10% | | |
| R35 | " | BC-0.25 | 150 ohm ±1% | | Selected for tolerance of ±10% with R15 from 150-ohm ±5% |
| R36 | " | BC | 2.4 kiloohm ±5% | | Selected from five BC-2 resistors in parallel 12-kilo-ohm ±10% |
| R37 | Fixed carbon resistor | BC-1 | 330 kiloohm±10% | | |
| R38 | Variable resistor | СП-1-2a | 100 kiloohm-A | | |
| R39 | Wire-wound vitrified resistor | ПО-10 | 500 ohm ±5% | | |
| R40 | Fixed carbon resistor | BC-0.25 | 600 ohm ±1% | | Selected during alignment with R14 from two BC-0.25 resistors 1200-ohm ±5% |

| Circuit designation | Description | Type | Data | Cipher | Note |
|---|---|---|---|---|---|
| R41 | Wire-wound vit- | ПО-10 | 700 ohm ±5% | | |
| R42 | Fixed carbon resistor | BC-0.25 | 5.6 kiloohm±10% | | Selected during alignment |
| R43 | Ditto | BC-0.25 | 2.7 megohm ±10% | | |
| R44 | Fixed carbon resistor | BC-0.25 | 2.7 megohm ±10% | | |
| R45 | Ditto | BC-0.5 | 360 kiloohm ±5% | | Selected during alignment |
| R46 | Fixed carbon resistor | BC-2 | 100 kiloohm ±10% | | Ditto |
| R47 | Variable resistor | СП-1-2а | 68 kiloohm-A | | |
| R48 | Fixed carbon resistor | BC-1 | 220 kiloohm ±10% | | |
| R49 | Variable resistor | СП-1-2а | 100 kiloohm-A | | |
| R50 | Fixed carbon resistor | BC-1 | 180 kiloohm ±10% | | |
| R51 | Variable resistor | СП-1-2а | 1 megohm-A | | |
| R52 | Fixed carbon resistor | BC-1 | 680 kiloohm ±10% | | Selected during alignment |
| R53 | Ditto | BC-1 | 56 kiloohm ±10% | | |
| R54 | " | BC-0.25 | 680 kiloohm ±10% | | |
| R55 | " | BC-0.25 | 56 kiloohm ±10% | | |
| R56 | " | BC-0.25 | 2.7 megohm ±10% | | |
| R57 | " | BC-0.25 | 2.7 megohm ±10% | | |
| R58 | " | BC-0.5 | 470 ohm ±10% | | |
| R59 | Fixed carbon resistor | BC-0.5 | 470 ohm ±10% | | Selected during alignment |
| R60 | Fixed carbon resistor | BC-1 | 22 kiloohm ±10% | | |
| R61 | Variable resistor | СП-1-2а | 1 megohm-A | | Ganged with resistor R64 |

| Circuit designation | Description | Type | Data | Cipher | Note |
|---|---|---|---|---|---|
| R62 | Fixed carbon resistor | BC-1 | 22 kiloohm±10% | | |
| R63 | Fixed carbon resistor | BC-0.5 | 22 kiloohm±10% | | Selected during alignment |
| R64 | Variable resistor | СП-1-2a | 1 megohm-A | | Ganged with resistor R61 |
| R65 | Fixed carbon resistor | BC-0.5 | 430 kiloohm±5% | | Selected during alignment |
| R66 | Fixed carbon resistor | BC-0.25 | 75 kiloohm±5% | | |
| R67 | Ditto | BC | 40 kiloohm±5% | | Selected from three BC-1 resistors 120-kiloohm±10% connected in parallel |
| R68 | " | BC-1 | 3.3 kiloohm±10% | | |
| R69 | Fixed carbon resistor | BC-1 | 100 kiloohm±10% | | |
| R70 | Ditto | BC-1 | 100 kiloohm±10% | | |
| R71 | " | BC-0.25 | 560 kiloohm±10% | | |
| R72 | " | BC-0.25 | 100 kiloohm±10% | | |
| R73 | " | BC-0.25 | 100 kiloohm±10% | | |
| R74 | Variable resis- | СП-1-2a | 10 kiloohm-A | | |
| R75 | Fixed carbon resistor | BC-0.5 | 1 megohm±10% | | |
| R76 | Ditto | BC-0.25 | 10 megohm±10% | | |
| R77 | " | BC-0.5 | 4.7 megohm±10% | | |
| R78 | Variable resistor | СП-1-2a | 4.7 kiloohm-A | | |
| R79 | Fixed carbon re- | BC-0.25 | 68 kiloohm±10% | | |
| R80 | Ditto | BC | 6.5 kiloohm±5% | | Selected from six BC-2 resistors 39-kiloohm±10% |

| Cir-cuit desig-nation | Description | Type | Data | Cipher | |
|---|---|---|---|---|---|
| R82 | Fixed carbon resistor | BC-2 | 6.5 kiloohm±10% | | |
| R84 | Fixed carbon resistor | BC | 8.5 kiloohm±5% | | Selected from [illegible] resistors connected in parallel: three [illegible]-kiloohm±10%; three 56-kiloohm±10% |
| R85 | Fixed carbon resistor | BC-1 | [illegible] kiloohm±10% | | |
| R86 | Variable resistor | CП-1-2a | 100 kiloohm-A | | |
| R87 | Wire-wound resistor | ПO-10 | 700 ohm ±5% | | |
| R88 | Fixed carbon resistor | BC-0.25 | 220 kiloohm±10% | | |
| R89 | Fixed carbon resistor | BC-0.25 | 22 kiloohm±10% | | |
| R90 | Ditto | BC-2 | 12 kiloohm±10% | | Selected from BC-2 resistors 24-kiloohm ±10% connected in parallel |
| R91 | " | BC-1 | 1.2 kiloohm±10% | | |
| R92 | " | BC-0.25 | 1 megohm ±10% | | |
| R93 | Fixed carbon resistor | BC-0.25 | 68 ohm ±10% | | |
| R94 | Fixed carbon resistor | BC-0.25 | 560 kiloohm±10% | | |
| R95 | Wire-wound resistor | ПO-10 | 7.5 kiloohm±10% | | |
| R96 | Fixed carbon resistor | BC-1 | 56 kiloohm ±10% | | |
| R97 | Ditto | BC | 13 kiloohm±5% | | Selected from three BC-1 resistors 39 kiloohm±10% |

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| Circuit designation | Description | Type | Data | Cipher | Note |
|---|---|---|---|---|---|
| | | | | | connected in parallel |
| R98 | Fixed carbon resistor | BC-1 | 2.7 kiloohm±10% | | |
| R99 | Fixed carbon resistor | BC-0.5 | 150 ohm ±10% | | |
| R100 | Variable resistor | CП-1-2a | 4.7 kiloohm-A | | |
| R101 | Fixed carbon resistor | BC-1 | 1.5 kiloohm±10% | | |
| R102 | Ditto | BC-0.25 | 500 kiloohm±10% | | |
| R103 | Fixed carbon resistor | BC-0.25 | 150 ohm ±10% | | |
| R104 | Ditto | BC-0.25 | 27 kiloohm±10% | | |
| R105 | " | BC-1 | 15 kiloohm±10% | | |
| R106 | Fixed carbon resistor | BC-1 | 15 kiloohm±10% | | |
| R107 | Variable resistor | CП-1-2a | 1 megohm-A | | |
| R108 | Fixed carbon resistor | BC-0.5 | 56 kiloohm±10% | | |
| R109 | Fixed carbon resistor | BC-1 | 10 kiloohm±10% | | |
| R110 | Fixed carbon resistor | BC-0.25 | 100 kiloohm±10% | | |
| R111 | Ditto | BC-0.25 | 1.5 kiloohm±10% | | Selected during alignment |
| R112 | " | BC-0.25 | 2.2 megohm±10% | | |
| R113 | " | BC-1 | 560 ohm±10% | | |
| R114 | " | BC | 25.5 kiloohm±5% | | Selected from BC-1 resistors connected in parallel: one 47-kiloohm ±10% and one 56-kiloohm ±10% |
| R115 | " | BC-0.25 | 560 ohm ±5% | | |

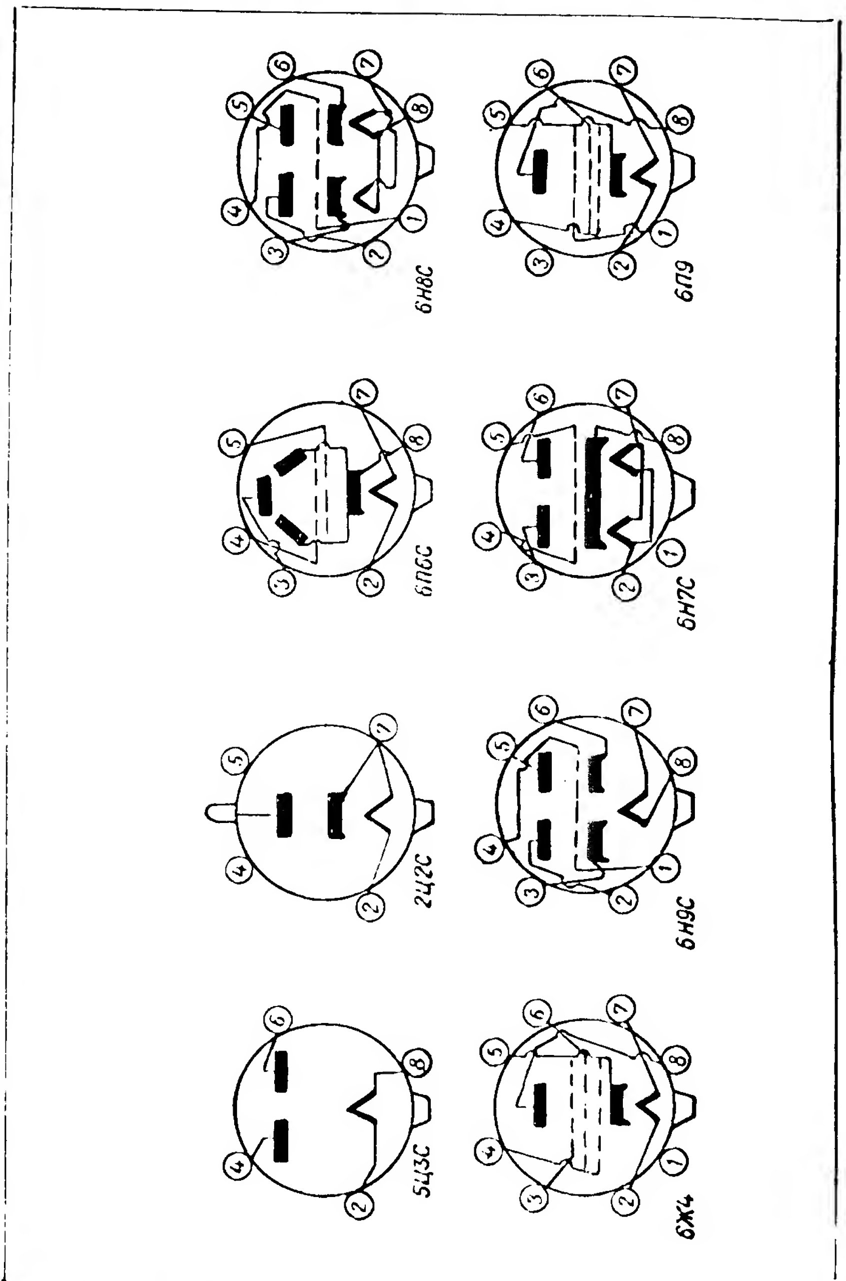
| Circuit designation | Description | Type | Data | Cipher | Note |
|---|---|---|---|---|---|
| R116 | Fixed carbon resistor | BC-0.25 | 15 kiloohm±10% | | |
| R117 | Ditto | BC-0.25 | 150 kiloohm±10% | | |
| R118 | " | BC-0.5 | 150 ohm ±10% | | |
| R119 | Fixed carbon resistor | BC | 15.7 kiloohm±10% | | Selected from three BC-1 resistors 47-kiloohm±10% connected in parallel |
| R120 | Ditto | BC-1 | 1.8 kiloohm±10% | | |
| R121 | Fixed carbon re- | BC | 9 kiloohm ±10% | | Selected from two BC-1 resistors 18-kiloohm ±10% connected in parallel |
| R122 | Ditto | BC-1 | 56 kiloohm±10% | | |
| R123 | " | BC-1 | 820 kiloohm±10% | | |
| R124 | Fixed carbon resistor | BC-0.25 | 68 ohm±10% | | Selected during alignment |
| R125 | Ditto | BC-0.5 | 3.6 megohm±10% | | |
| МЛ | Delay line | | | 25м-об.06 | Twenty-four KTK-1-M ceramic cond. 39mmf±10%; 500 v. Selected for mutual tol. of 1mmf in each line |
| R127 | Fixed carbon resistor | BC-0.25 | 75 kiloohm±5% | | |
| L2 | Induction coil | | 35 Microhenry | 25м-об.43 | |
| L3 | Ditto | | 35 Microhenry | 25м-об.43 | |
| L4 | " | | 35 Microhenry ±5% | 25м-об.43 | |
| L5 | " | | 35 Microhenry | 25м-об.43 | |

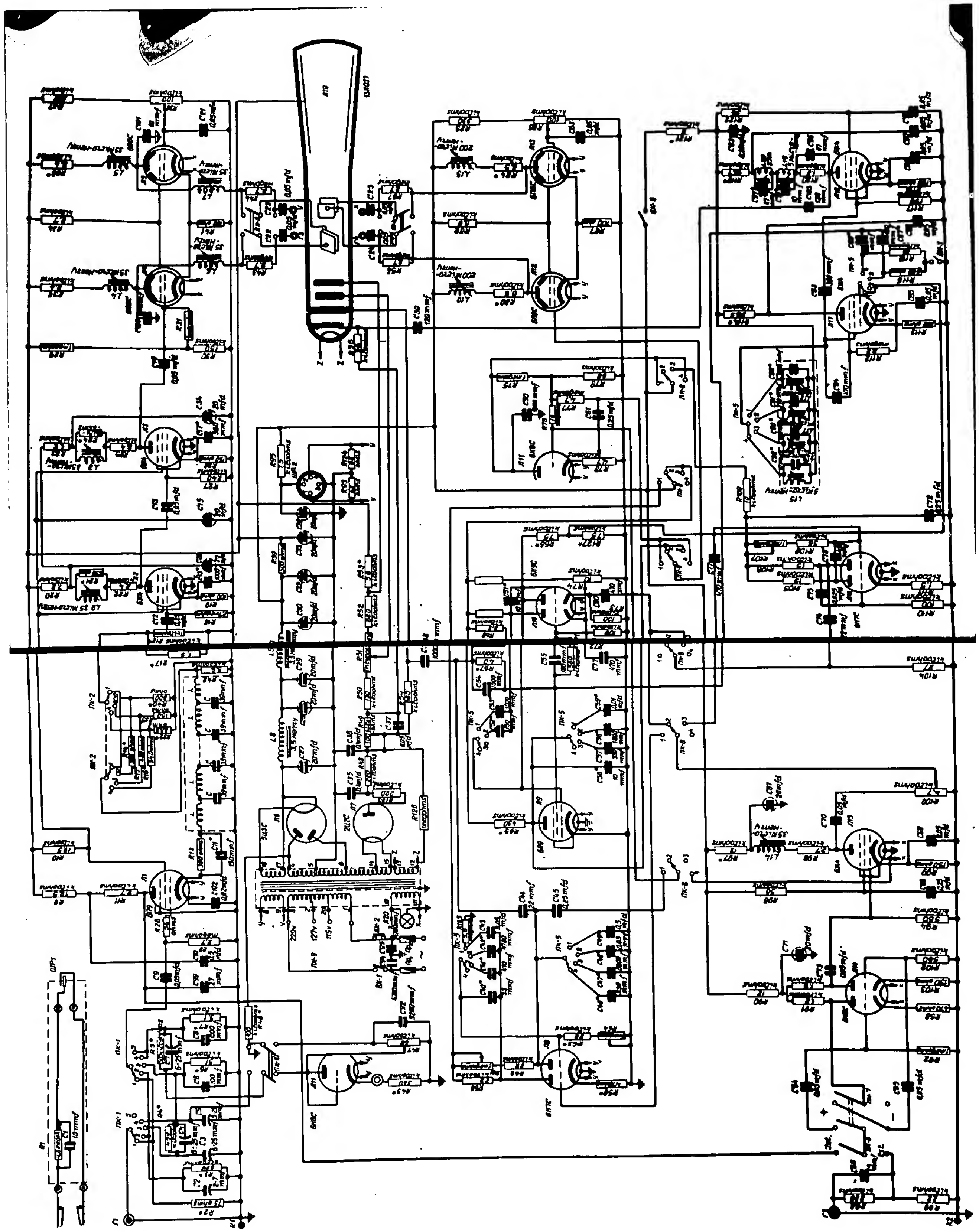
| Circuit designation | Description | Type | Data | Cipher | Note |
|---|---|---|---|---|---|
| L6 | Induction coil | | 35 Microhenry | 25н-оδ.43 | |
| L7 | Ditto | | 35 Microhenry | 25н-оδ.43 | |
| L8 | Filter choke | | 3.5 Henry | 25н-оδ.05 | |
| L9 | Filter choke | | 3.5 Henry | 25н-оδ.05 | |
| L10 | Induction coil | | 200 Microhenry | 25н-оδ.41 | |
| L13 | Induction coil | | 200 Microhenry | 25н-оδ.41 | |
| L14 | Ditto | | 35 Microhenry | 25н-оδ.43 | |
| L15 | " | | 5 Microhenry | 25н-оδ.69 | |
| L16 | " | | 35 Microhenry | 25н-оδ.43 | |
| L17 | " | | 200 Microhenry | 25н-оδ.70 | |
| L18 | " | | 1600 Microhenry | 25н-оδ.68 | |
| L19 | " | | 5 Microhenry | 25н-оδ.39 | |
| L20 | " | | 35 Microhenry | 25н-оδ.43 | |
| T-1 | Transformer | 25н-оδ.04 | | | |
| ПК-1 | Wafer switch five position, 2 pole | 25н-оδ.09 | | | |
| ПК-2 | Wafer switch four position 6 pole | 25н-оδ.10 | | | |
| ПК-3 | Two-pole switch | 25н-оδ.20 | | | |
| ПК-4 | Two-pole switch | 25н-оδ.20 | | | |
| ПК-5 | Wafer switch four position 6 pole | 25н-оδ.11 | | | |
| ПК-6 | Single-pole switch | 25н-оδ.55 | | | |
| ПК-7 | Two-pole switch | 25н-оδ.20 | | | |
| ПК-8 | Wafer switch four position 6 pole | 25н-оδ.11 | | | |

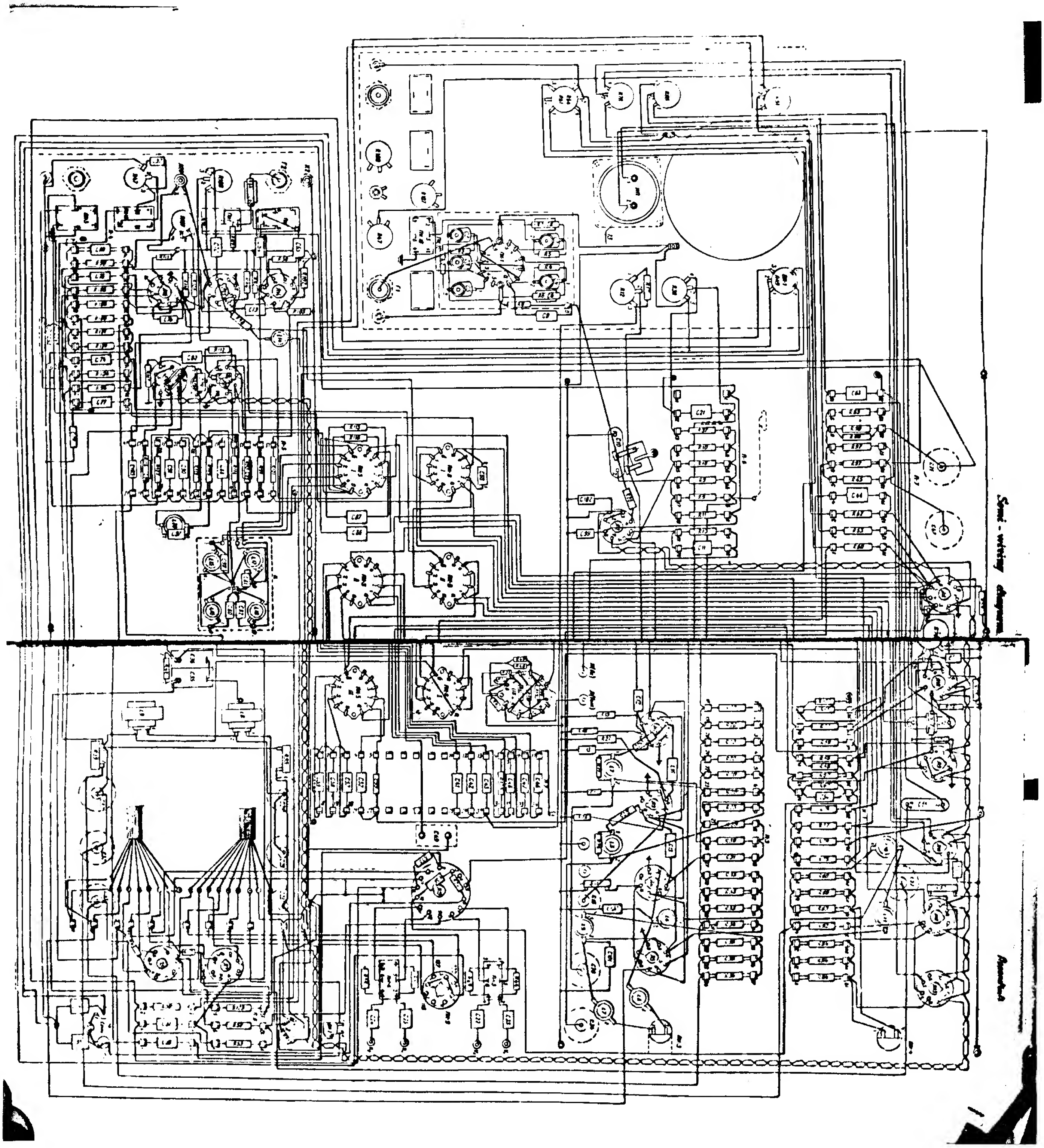
| Circuit designation | Description | Type | Data | Cipher | Note |
|---|---|---|---|---|---|
| ПК-9 | Supply-voltage switch | 25н-сб.23 | | | |
| ПК-10 | Two-pole switch | 25н-сб.20 | | | |
| ВК-1 | Single-pole switch | 25н-сб.55 | | | |
| ВК-2 | Interlock button | 06672-15 | 04702 | | |
| ВК-3 | Two-pole switch | 25н-сб.20 | | | |
| ШР-1 | Coaxial plug | ШР28П4-8 | | | |
| ШР-2 | Coaxial receptacle | ШР28П4-8 | | | |
| ПР | Fuse СП 2 amps | | | | |
| К | Ground binding post | 25н-сб.26 | | | |
| ИП | Meter МС-100 | 25н-сб.111 | | | |
| 1 | Coaxial jack | 25н-сб.63 | | | |
| 2 | Coaxial jack | 25н-сб.63 | | | |
| 3 | Jack | | | 25н-сб.22 | |
| 4 | Jack | | | 25н-сб.22 | |
| C103 | Mica condenser | КСО-6 | 120 mmf; 1000 v. | | |
| R126 | Fixed resistor | ВС-0.5 | 1 megohm ±10% | | |

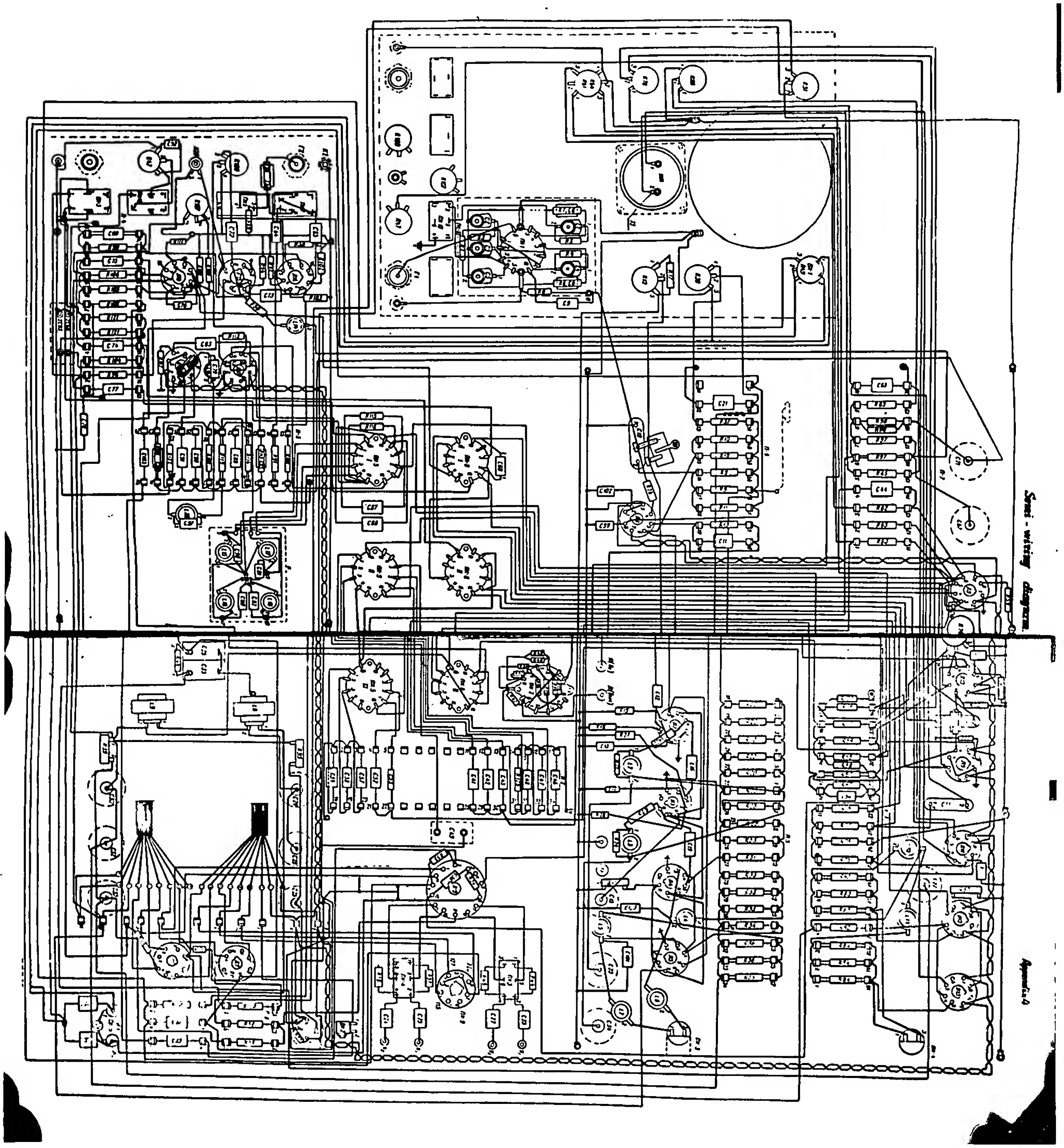
Appendix 5

**Internal Connections of Valves**



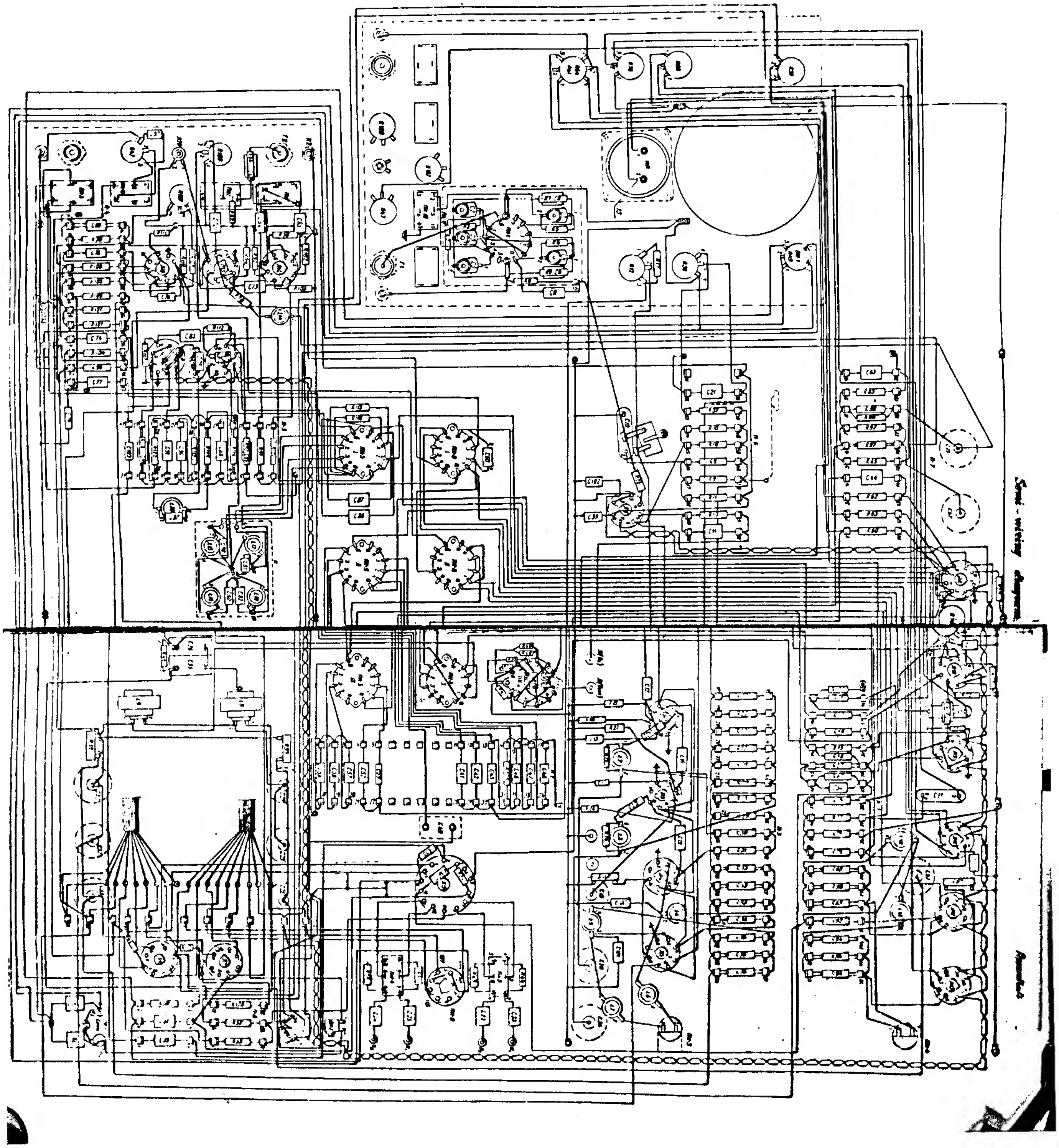



Semi - wiring diagram



Semi - wiring diagram.

Appendix 6


Semi - wiring diagram